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16. ABSTRACT

A prototype swirl degritter was tested by the Metropolitan Denver Sewage Disposal District No. 1. The unit was designed to duplicate the grit removal device needed to degrit the underflow from the proposed swirl concentrator as a combined sewer overflow regulator at Lancaster, Pennsylvania under EPA Grant No. S802219 (formerly 11022 GBC). Degritting is considered in Lancaster to protect pumps and prevent siltation in the interceptor.

The 1.8 m (6 ft) diameter device was designed for a flow of 65.6 l/s (1.3 mgd). It was found that under the physical arrangements in Denver, testing with domestic sanitary wastewater, the swirl unit performed at slightly less efficiency than the conventional aerated grit unit which was operating at less than twice the normal flow-through rate. The characteristics of the grit removal from the swirl degritter were excellent and particles of 0.5 mm (.012 in.) were removed.

Analyses of grit removal was accomplished with three Chasnov sampling units. Blasting sand was added to provide extremely high concentrations of 0.2 mm (.008 in.) particles (lower definition of grit) to duplicate the concentrate from the swirl regulator. It was found that the unit could efficiently remove the small particles at the high concentrations.

It was concluded that the degritter could be used for domestic wastewater, combined sewer overflows, or urban stormwater runoff treatment. The absence of moving parts in the basic unit and small relative volume 1:10 (compared to conventional grit chambers) may make the unit particularly desirable for many applications. A comparison of the present worth of the cost of construction, operation, and maintenance for a 20 year life indicates that the swirl degritter is from 25 to 35 percent less costly than a conventional aerated grit chamber.

This report is submitted in partial fulfillment of EPA Grant S803157 by the American Public Works Association under the sponsorship of the U.S. Environmental Protection Agency. This report covers a period from January 1975 to August 1976, and work was completed as of December 1976.

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FIELD PROTOTYPE DEMONSTRATION OF THE SWIRL DEGRITTER

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FOREWORD

The Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimony to the deterioration of our natural environment. The complexity of that environment and the interplay between its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution and it involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems for the prevention, treatment, and management of wastewater and solid and hazardous waste pollutant discharges from municipal and community sources, for the preservation and treatment of public drinking water supplies and to minimize the adverse economic, social, health, and aesthetic effects of pollution. This publication is one of the products of that research; a most vital communications link between the researcher and the user community.

The study describes the evaluation of a prototype swirl degritter to perform the function of grit separation more effectively than conventional units for concentrated grit as may be found in the treatment of stormwater discharges.

Francis T. Mayo
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ABSTRACT

A prototype swirl degritter was tested by the Metropolitan Denver Sewage Disposal District No. 1. The unit was designed to duplicate the grit removal device needed to degrit the underflow from the proposed swirl concentrator as a combined sewer overflow regulator at Lancaster, Pennsylvania under EPA Grant No. S802219 (formerly 11023 GEC). Degritting is considered in Lancaster to protect pumps and prevent siltation in the interceptor.

The 1.8 m (6 ft) diameter device was designed for a flow of 65.6 l/s (1.5 mgd). It was found that under the physical arrangements in Denver, and testing with domestic sanitary wastewater, that the swirl unit performed at slightly less efficiency than the conventional aerated grit unit which was operating at less than twice the normal flow-through rate. The characteristics of the grit removal from the swirl degritter were excellent and particles of 0.2 mm (.008 in) were removed.

Analyses of grit removal was accomplished with three Chaetch sampling units. Blasting sand was added to provide extremely high concentrations of 0.2 mm (.008 in) particles (lower definition of grit) to duplicate the concentrate from the swirl regulator. It was found that the unit could efficiently remove the small particles at the high concentrations.

It was concluded that the degritter could be used for domestic wastewater, combined sewer overflows, or urban stormwater runoff treatment. The absence of moving parts in the basic unit and small relative volume 1:10 (compared to conventional grit chambers) may make the unit particularly desirable for many applications. A comparison of the present worth of the cost of construction, operation and maintenance for a 20-year life indicates that the swirl degritter is from 26 to 38 percent less costly than a conventional aerated grit chamber.

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CONTENTS

Foreword iii

Abstract iv

Figures vi

Tables viii

Acknowledgments x

1. Conclusions and Recommendations 1

2. The Demonstration Project 2

3. Description of the Test Layout 5

4. Evaluation of Test Results 11

References 55

Appendix

A. Test Data, Denver, Colorado 56

FIGURES

Number		Page
1	Isometric View, Swirl Degritter	4
2	Layout for Denver Tests	6
3	Plan of Swirl Degritter	7
4	Section A-A of Swirl Degritter	8
5	Section B-B of Swirl Degritter	9
6	Chesick Grit Sampler	11
7	Denver Tests Grit Gradation Curves, 5/23-6/21, First Series	19
8	Gradation Curve of Spiking Sand	22
9	Removal of Dry Grit, 8/75	26
10	Weight of Dry Grit, 8/75	27
11	Removal of Grit Ash, 8/75	31
12	Weight of Grit Ash, 8/75	32
13	Grit Gradation Curves, Run No. 1, 8/75	41
14	Grit Gradation Curves, Run No. 2, 8/27/75	41
15	Grit Gradation Curves, Run No. 3, 8/27/75	41
16	Grit Gradation Curves, Run No. 4, 8/27/75	41
17	Grit Gradation Curves, Run No. 5, 8/27/75	42
18	Grit Gradation Curves, Run No. 1, 8/28/75	42
19	Grit Gradation Curves, Run No. 2, 8/28/75	42
20	Grit Gradation Curves, Run No. 3, 8/28/75	43
21	Grit Gradation Curves, Run No. 4, 8/28/75	43

FIGURES (continued)

Number		Page
22	Grit Gradation Curves, Run No. 5, 8/28/75	43
23	Grit Gradation Curves, Run No. 1, 8/29/75	43
24	Grit Gradation Curves, Run No. 2, 8/29/75	43
25	Grit Gradation Curves, Run No. 3, 8/29/75	44
26	Grit Gradation Curves, Run No. 4, 8/29/75	44
27	Grit Gradation Curves, Run No. 5, 8/29/75	44
28	Grit Gradation Curves, Run No. 1, 8/30/75	44
29	Grit Gradation Curves, Run No. 2, 8/30/75	45
30	Grit Gradation Curves, Run No. 3, 8/30/75	45
31	Grit Gradation Curves, Run No. 4, 8/30/75	45
32	Grit Gradation Curves, Run No. 5, 8/30/75	45

TABLES

Number		Page
1	Detention Times	10
2	Proposed Tests-First Series--5/23-6/21/75	14
3	Removal of Grit Ash--5/23-6/21/75	16
4	Removal of Dry Grit--5/23-6/21/75	17
5	Removal of Suspended and Volatile Solids--5/23-6/21/75	18
6	Proposed Tests Seconds Series--8/27-8/31/75	21
7	Removal of Dry Grit--8/27-8/30/75	23
8	Removal of Grit Ash--8/27/75	24
9	Removal of Grit Ash--8/28/75	26
10	Removal of Grit Ash--8/29/75	29
11	Removal of Grit Ash--8/30/75	30
12	Removal of Volatile Solids--5/23 to 6/21/75	33
13	Removal of Volatile Solids--8/27/75	34
14	Removal of Volatile Solids--8/28/75	35
15	Removal of Volatile Solids--8/29/75	36
16	Removal of Volatile Solids--8/30/75	37
17	Aerated Grit Chamber, Single Chamber High Flow Efficiency	46
18	Construction Cost of Swirl Degritter	50
19	Construction Cost of Conventional Aerated Grit Chamber	51
20	Operation and Maintenance Costs for Grit Removal	53
21	Present Worth, Grit Removal Units	54

TABLES (continued)

Number		Page
A-1	Test Data Swirl Flow 43.8 l/s (1.0 mgd), 5/23-5/29/75	56
A-2	Test Data Swirl Flow 87.6 l/s (2.0 mgd), 5/31-6/6/75	57
A-3	Test Data Swirl Flow 131.4 l/s (3.0 mgd), 6/12-16 & 20-21/75	58
A-4	Test Data Swirl Flow 21.9 l/s (0.5 mgd), 6/27/75	59
A-5	Test Data Swirl Flow 43.8 l/s (1.0 mgd), 6/28/75	60
A-6	Test Data Swirl Flow 87.6 l/s (2.0 mgd), 6/29/75	61
A-7	Test Data Swirl Flow 131.4 l/s (3.0 mgd), 6/30/75	62
A-8	Aerated Grit Chamber Data, Single Chamber High Flow	63

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SECTION I

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

1. The swirl degritter can efficiently and effectively remove grit from all wastewater flows. Even though the percent dry grit removal in the aerated grit chamber for raw sanitary sewage was consistently higher (77.3 percent) than that accomplished in the swirl degritter (66.4 percent), the aerated grit chamber retained an undesirably higher percentage of organic particles (volatile solids) than the swirl unit (19-30 percent for the aerated grit chamber as compared to 3-10 percent for the swirl degritter). To test the effectiveness of the swirl degritter in removing grit from combined sewer overflow and overflow concentrate, the plant influent was spiked by adding blasting sand (0.20 mm size). Removal efficiencies under these conditions were improved for the swirl unit. They ranged from 50 to 87 percent for the swirl degritter; and for the aerated grit chamber the range was considerably lower.

2. The swirl degritter remains effective at flows of twice the design flow. Efficiency falls off markedly at three times design flow, which is similar to other types of degritters.

3. Because the swirl degritter is compact in size and has no moving parts it is attractive for application on stormwater, combined sewer overflows, or treatment at remote locations where maintenance capability is limited. Such degritting may be desirable prior to pumping of the flows.

4. Since the swirl unit requires no aeration or moving parts in its internal operation, energy consumption/unit flowrate for this unit is less than any other method of grit removal.

5. Because of the mechanics of flow in the swirl degritter, the detention time in the unit is one minute or less as compared to a standard design of about three minutes for a conventional aerated grit chamber.

6. The present worth, including construction, operation, and maintenance of the swirl degritter compared to an aerated grit chamber indicates a savings of 26 percent for a 43.8 l/s (1 mgd) unit to 38 percent for a 438 l/s (10 mgd) unit.

RECOMMENDATIONS

1. The City of Lancaster, in conjunction with the construction of a swirl concentrator as a combined sewer overflow regulator, should consider constructing a swirl concentrator as a grit chamber to reduce maintenance on its lift pumps.

2. Agencies that construct swirl degritters should be encouraged to install Chastch sampling units on the influent and effluent lines to enable further testing of the efficiency of the units.

SECTION II

THE DEMONSTRATION PROJECT

A related family of research studies has been carried out during the past four years to determine the ability of solids-liquids separation flow-through devices to remove unwanted solids in wastewater flows by means of induced swirl pattern hydraulic flows in time periods shorter than those required by conventional gravity separation treatment systems. The success of laboratory-based investigations in small-scale chambers on synthesized wastewater flows has led, progressively, to consideration and study of the application of such swirl concentration chambers for such purposes as combined sewer overflow regulation, grit removal from wastewater flows, primary clarification of wastewaters and erosion control devices.

A "first-generation" study was carried out on behalf of the U.S. Environmental Protection Agency (USEPA), by the American Public Works Association (APWA) Research Foundation to develop and investigate the feasibility of utilizing a swirl device to perform the dual function of hydraulically regulating overflows from a combined sewer system while simultaneously reducing the solids content and pollutional characteristics of the overflows discharged to receiving water by solids-liquid separation. The first report (1) recognized the applicability of the swirl separation principle for other than the combined sewer overflow regulator-separator.

It is obvious that a natural application of this relatively "flash-type" solids-liquid phase separation would be the removal of heavier grit from wastewater flows because such solids are more readily treatable because of their higher settling velocities. It was a new innovation in the separation of heavy inorganic solids from lighter organic materials by selective use of longitudinal flow velocities. It also offered opportunities to effectively remove grit from either the underflow concentrate (foul sewer discharge), of a swirl concentrator combined sewer overflow regulator or from normal dry-weather and wet-weather influents into treatment plants.

A "second-generation" study followed to develop and evaluate the swirl concentrator for grit removal for a planned installation of such a device for the City of Lancaster, Pennsylvania, (2) as part of a system for the treatment-disinfection of combined sewer overflow and pumping of the concentrated underflow back into the interceptor to the treatment plant. Removal of grit was intended to protect the wet well and pumping units of this proposed installation from the eroding and siltation effects of solids concentrations as high as 13,000 mg/l as well as reduce the effects of deposition in the downstream interceptor.

The report on that study (2) described the study procedure, reported on the successful findings, outlined methods of design for prototype field swirl grit concentrator facilities, and recommended that confirmation of the application of the swirl concentrator principle to grit removal be undertaken in a prototype unit which would handle actual wastewater flows rather than synthetic materials in the laboratory for test purposes.

The studies (2) of grit handling undertaken at the LaSalle Hydraulic Laboratory, LaSalle, Canada, were performed for the City of Lancaster, with the specific application defined to meet the needs of the proposed combined sewer overflow, regulator facility, i.e., to separate grit from its underflow concentrate, but the research project produced findings and prototype design parameters which would be translated into installations for other purposes, e.g., conventional grit removal in other locations.

Based on the findings and design parameters for the swirl degritter from the hydraulic laboratory study, (2) the Metropolitan Denver Sewage Disposal District No. 1 fabricated a prototype unit.

Based on the findings and recommendations contained in the swirl degritter development report, (2) and the availability of the prototype unit at Denver which could be operated in parallel with existing grit removal facilities at the treatment plant, a demonstration grant was negotiated to investigate the Denver unit, (EPA Grant No. S-803157). The Denver grit study was coupled under the same grant, EPA No. S-308157, with field evaluation of the swirl primary clarifier, carried out at the Municipality of Metropolitan Toronto, Canada, in participation with the Canadian Ministry of the Environment. A report on the primary clarification studies is contained elsewhere as part of the overall report on this "third-generation" of swirl concentrator as a primary separator.

The Denver evaluation represents a rational procedure of investigative techniques on a prototype swirl degritter with real sewage. The hydraulic laboratory developmental studies at the LaSalle Hydraulic Laboratory, (2) resulted in design procedures. However, such studies must be confirmed under actual conditions with real wastewater. Prototype investigations in the field are needed to assure designers of the practical applicability of laboratory-based determinations to realistic on-site operational conditions, thus the Denver studies were designed to provide this sequential research procedure.

The opportunity to compare prototype swirl degritter performance with conventional aerated grit chamber facilities converts the theory into reality.

Before the evaluation grant was instituted, preliminary installation and shakedown work had been carried out at the Denver installation. Figure 1 is an isometric drawing of the test unit.

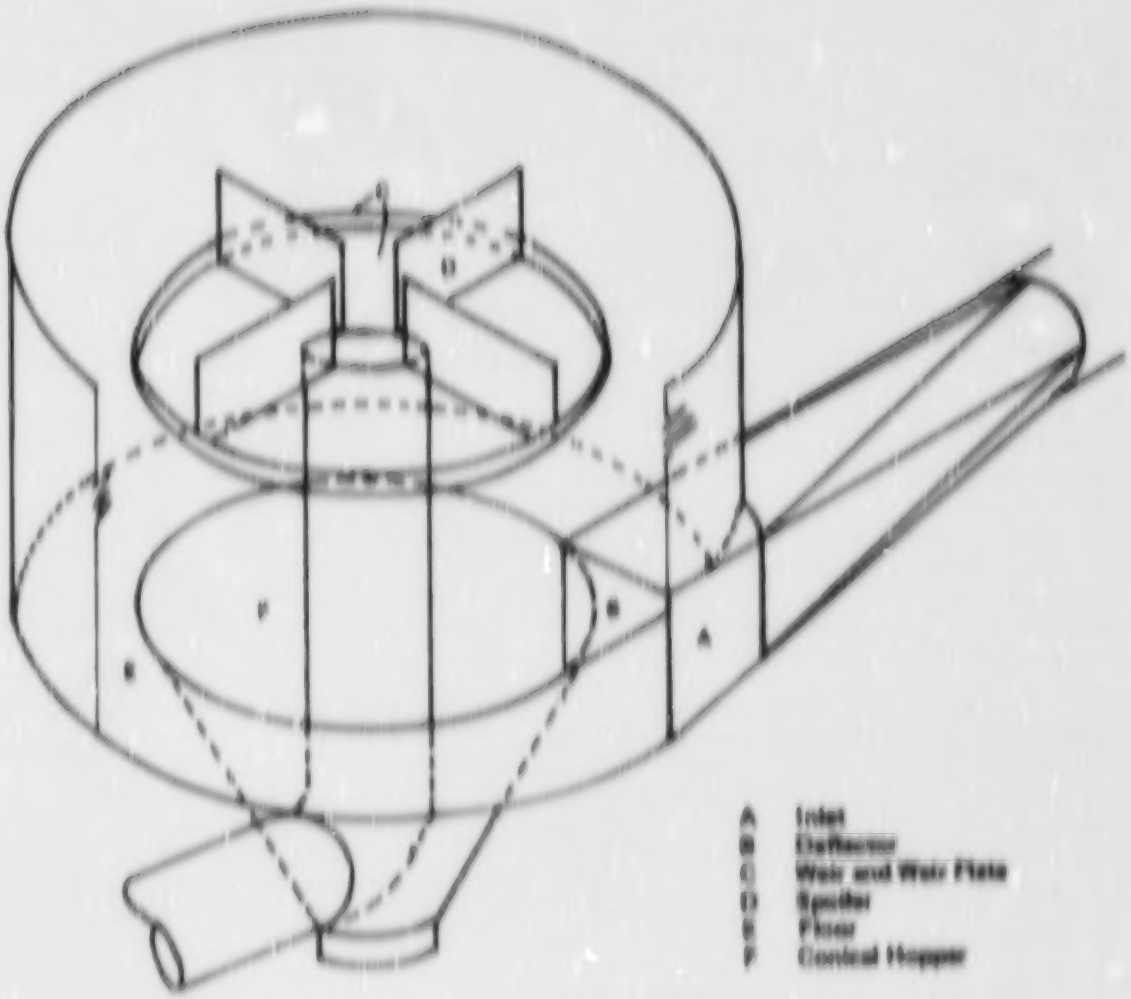


FIGURE 1 ISOMETRIC VIEW, SWIRL DEGRITTER

SECTION III

DESCRIPTION OF THE TEST LAYOUT

The prototype swirl degritter installation at the Metropolitan Denver Sewage Disposal District No. 1 treatment plant has two purposes: to ascertain the grit removal efficiency of the test system, and to compare these results with the grit removal performance of the plant's conventional aerated grit chamber (AGC). The layout of the swirl system, in relation to the plant's aerated grit removal facilities has been planned to make these two functions attainable. This installation is shown on Figure 2.

The 43.8 l/sec (1.0 mgd) swirl unit was constructed in 1974 at a cost of $4,500 exclusive of pumps, valves and grit washer elements which were readily available to the District. The cost of a comparison conventional grit removal unit of the same design flow is approximately $57,500.

Sewage for the swirl degritter was pumped from the influent channel to the AGC. The problem was to ascertain that the sewage delivered to the swirl degritter contained the same grit as the sewage entering the AGC. Sampling of the flow in the influent channel indicated that the solids were not evenly distributed in the channel. A baffle plate was installed initially to produce turbulence but sampling indicated this did not provide an even distribution of the grit and other suspended solids. An air header with six precision-type tubes was then installed and subsequent sampling indicated that the solids distribution was satisfactory. This procedure of assuring uniform concentrations of grit in the pumped sample reduced the settling efficiency in the swirl degritter since the solids would normally enter the swirl degritter as a stratified sewer load. The procedure did not affect the AGC efficiency. As a result both the evaluations of the swirl degritter and its comparison with the AGC are believed to be conservative.

The sewage was raised to a Parshall flume by two 15 cm (6 in) self-priming solids-handling pumps, each with a capacity of 78.8 l/s (1.8 mgd). The suction hoses for the two pumps were located to pick up sewage at the same point so that the use of either pump would obtain similar sewage samples. The pumps delivered the sewage into a channel set about 1.81 m (6 ft) above the ground, which discharged through a 22.8 cm (9 in) Parshall flume to measure the flow prior to entry into the swirl degritter. Grit was discharged from the bottom of the swirl degritter into a standard grit elevator and washer and after sampling, was returned to the AGC. Effluent from the swirl degritter was also returned to the AGC after sampling.

Details of the swirl degritter are shown in Figures 3, 4 and 5. The diameter selected was 1.8m (6 ft) and the other dimensions were chosen to

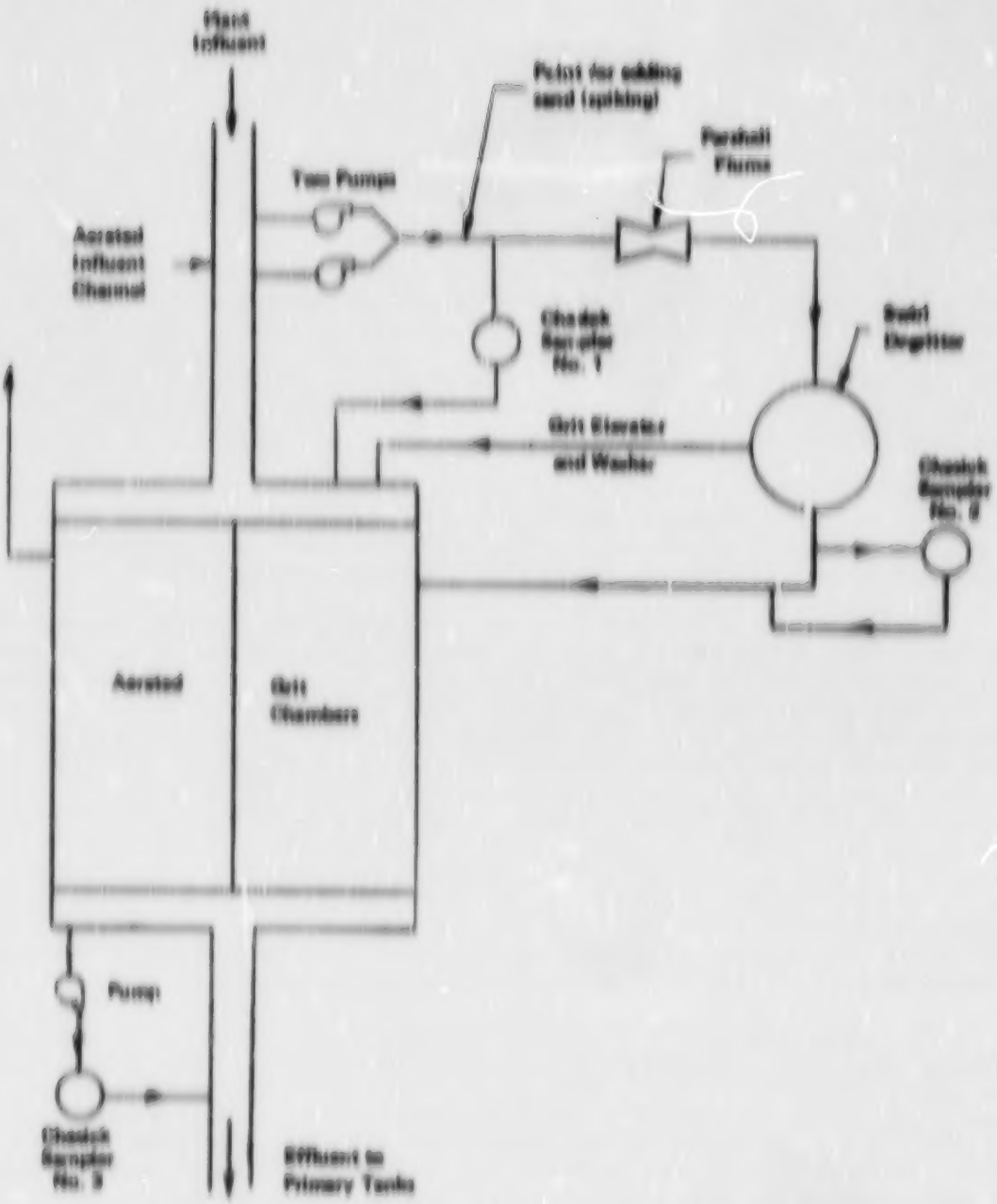
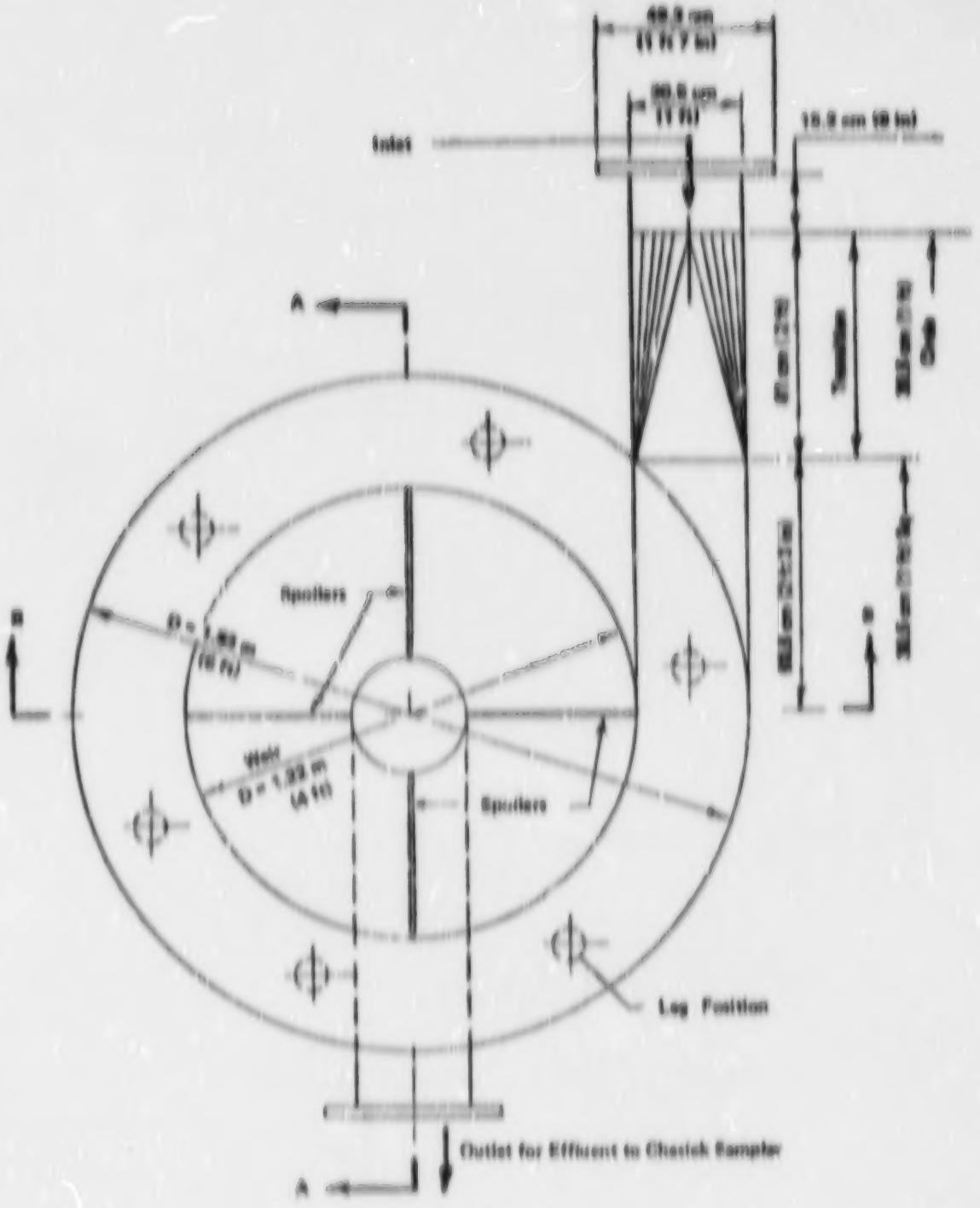
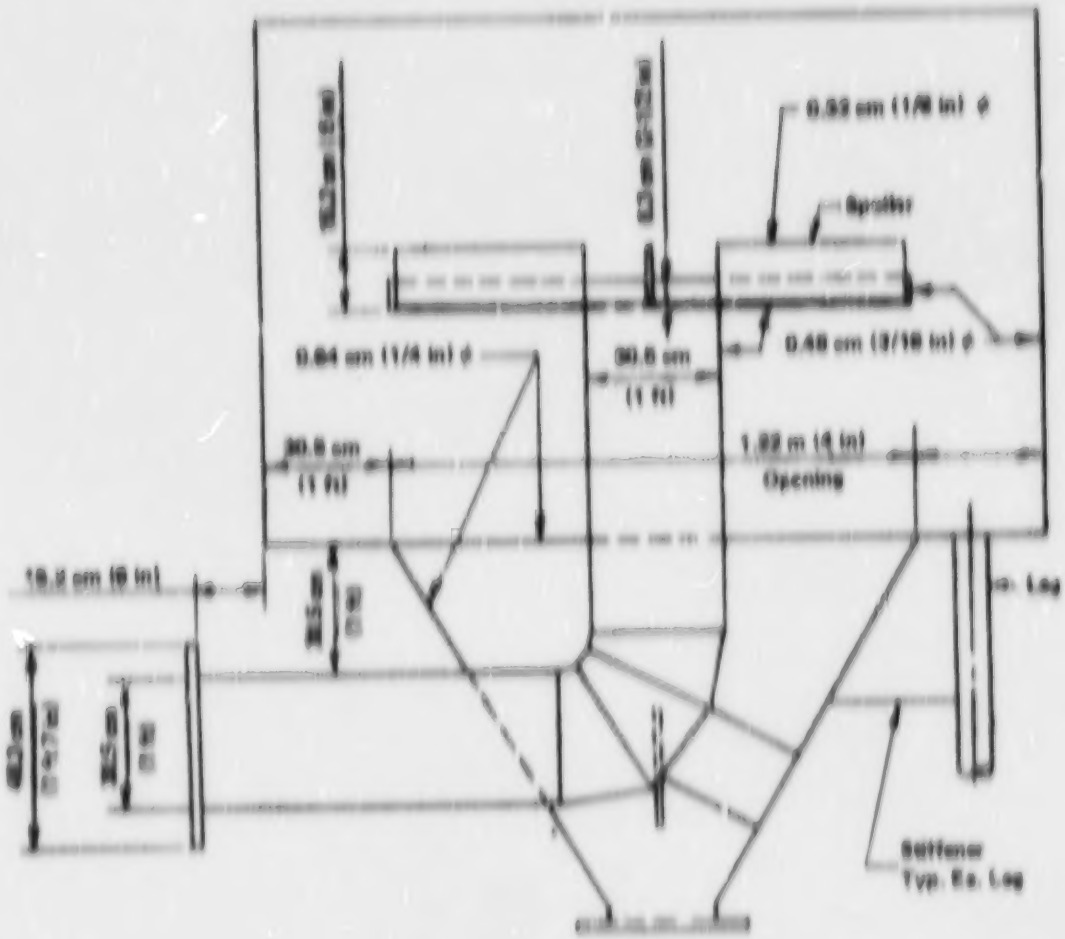


FIGURE 2 LAYOUT FOR DENVER TESTS



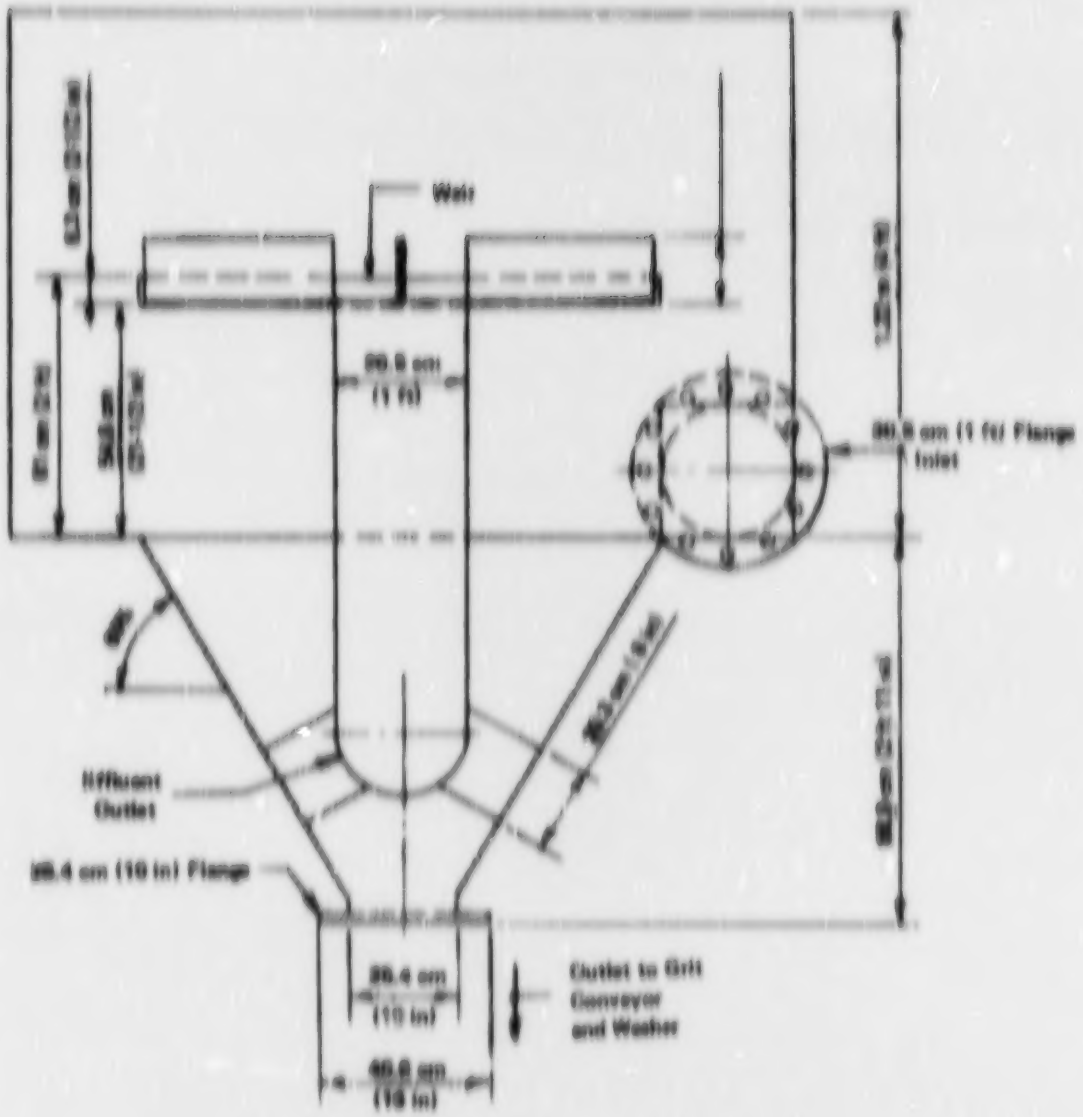
PLAN

FIGURE 3 PLAN OF SWIRL DEGRITTER



SECTION A A

FIGURE 4 SECTION A–A OF SWIRL DESPRITTER



SECTION B-B

FIGURE 5 SECTION B–B OF SWIRL DEGRITTER

agree with Figure 3 of the laboratory model study (2). Excluding the volume in the cone-shaped hopper the detention time in the swirl degritter for various flows is shown in Table 1, based on the net volume in the main chamber being 1,486 l (52.5 cf).

TABLE 1. DETENTION TIMES

Flow				Actual Detention Time		Detention Time
AGC		Swirl Degritter 1.8 m (6 ft)		AGC (1)	Swirl Degritter, Tm, 1.8 m (6 ft)	Prototype Swirl, Tp (2),
l/s	mgd	l/s	mgd	min	min	min
438	10	21.9	0.5	40	1.1	3.00
876	20	43.8	1.0	20	0.6	1.09
1,952	40	87.6	2.0	8	0.3	0.55
2,190	50	131.4	3.0	8	0.2	0.35

Note 1: Conventional design basis 3 to 5 minutes
2: From Froude number equation $Tp = Qp^{1/5}/Qm^{1/5}(Tm)$ for swirl degritter prototype flow of 438 to 2,190 l/sec (10 to 50 mgd)

The transition length of pipe used at the inlet was only two inlet diameters because the unit was constructed prior to completion of the laboratory studies. The recommended length as shown in reference (2) is three diameters.

The aerated grit chamber was designed to remove both grit and grease. The initial design average flow was 876 l/s (20mgd), based on a 20-minute detention time. The unit was originally designed with a long detention time to facilitate removal of grease. During the study tests, flows in the aerated grit chamber approached 2,190 l/s (50 mgd), the detention time was about eight minutes. The usual basis for design of aerated grit chambers is to provide about three minutes detention time at peak flow. In a large plant like Denver, where the peak flow may be two times average flow, the detention time for average flow would be about six minutes.

In most cases, the rational design of grit chambers is based on removing particles over 0.20 mm or 0.25 mm in size with s.g. of 2.65, U.S. Standard Sieve number 70 has an opening of 0.21 mm. Little data are available on the percentage of grit removed in entering grit chambers over any given size. It is common knowledge that grit over 0.20 mm in size is found in plant units following grit removal (2).

It was considered necessary for purposes of this study to determine the presence of grit over 0.20 mm in size in the influent and effluent sewage of the aerated grit chamber and the swirl degritter. For this purpose it was decided to use the model grit cyclone developed by A.H. Chastick

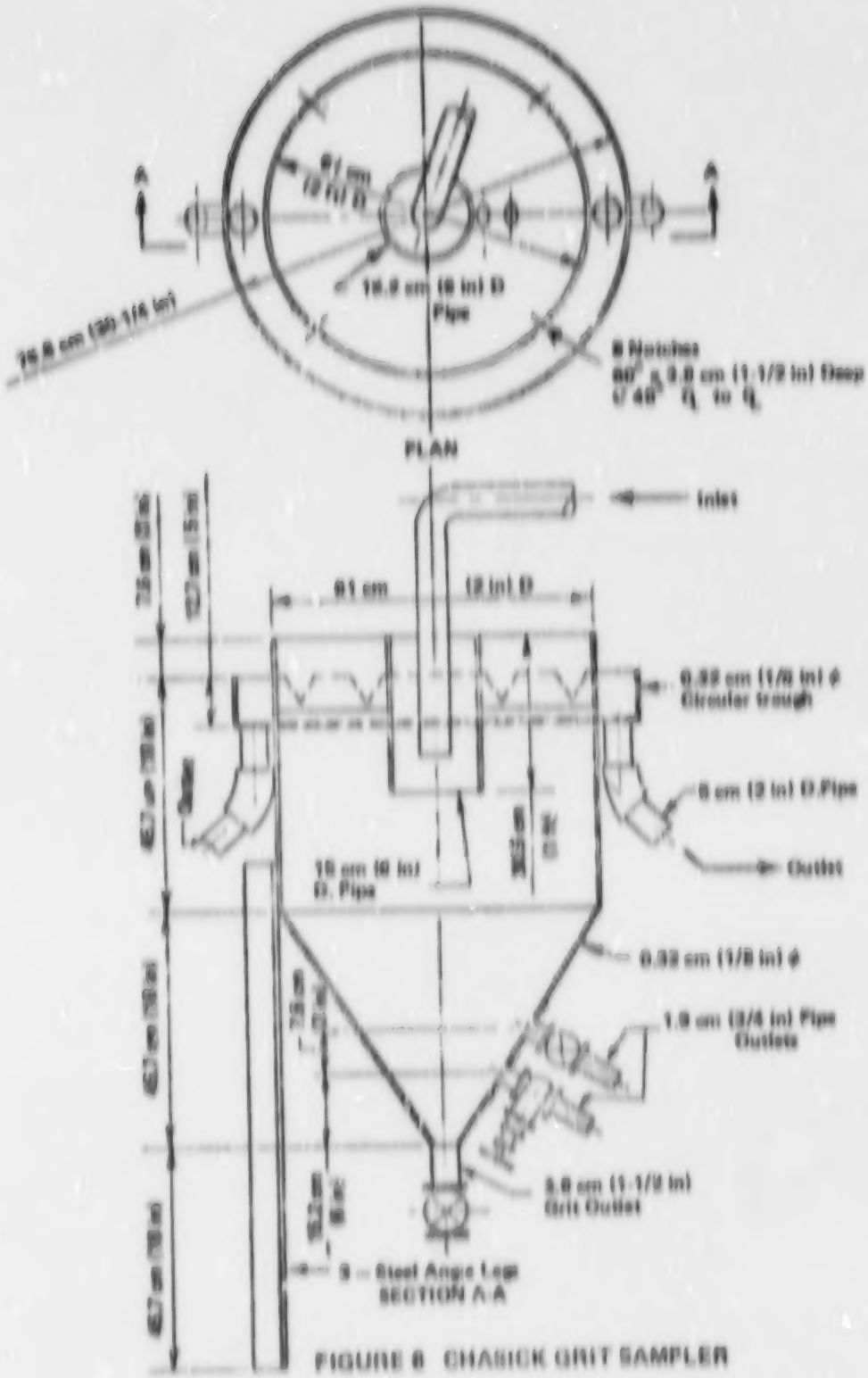


FIGURE 8 CHABICK GRIT SAMPLER

and T.R. Burger (3), as a sampling device. This grit cyclone is shown in Figure 6 and is referred to in this report as the Chastek sampler. Experiments by Chastek and Burger indicated the percent recovery of various size sands for various overflow rates.

Initially, in Denver, it was proposed to use and overflow rate of 814.6 $m^3/d/m^2$ (20,000 gpd/sf) on the Chastek samplers, but this flow resulted in the deposition of so much grit that these units had to be emptied every hour. Therefore the overflow rate was reduced to 407.3 $m^3/d/m^2$ (10,000 gpd/sf). This overflow rate is equivalent to an inlet flow of 1.38 l/s (21.8 gpm). According to Chastek and Burger, (3) this overflow rate should result in capturing 100 percent of the grit larger than 0.20 mm in the Chastek sampler. Three Chastek samplers were installed as shown in Figure 2: No. 1 to determine the grit in the influent to the plant, and therefore to the AGC and the swirl degritter; No. 2 for the effluent from the swirl degritter; and No. 3 for the effluent from the AGC. Gravity flow was possible to Chastek samplers No. 1 and No. 2, but it was necessary to pump up into Chastek sampler No.3.

In the second series of tests, dry blasting sand, size 0.23 mm, was added to the sewage after it was pumped from the influent channel. The point where sand was added is shown if Figure 2. Because of the location of the sand injector, only Chastek samplers Nos. 1 and 2 were effected by this addition. Therefore, results from these two samplers could not be compared to the test results from Chastek sampler No. 3 when the flow was enriched with sand. The process of sand addition is called spiking in this report.

SECTION IV

EVALUATION OF TEST RESULTS

The first series of tests were established to evaluate flows of 43.8, 87.6 and 131.6 l/s (1.0, 2.0, and 3.0 mgd) in the swirl degritter. The sampling points and proposed tests are shown in Table 2. The test run for each flow was to be seven consecutive days. However, during the test run for a flow of 131.6 l/s (3.0 mgd) the tests were interrupted for three days. The results are shown in Tables A-1, A-2, and A-3 in the Appendix.

The data on grit removal for the first series of tests are shown in Table 3. The weight of dry grit is converted to the weight of grit ash in the table on the basis of the percent of volatile solids. The percentage removal of grit ash in the swirl degritter ranged from 68.0 to 84.2 percent, with an average of 76.0 percent. The highest percent removal occurred with the highest flow rather than with the lowest flows, as might be expected. The removals in the ACC ranged from 86.8 to 92.7 percent with an average of 89.8 percent. Therefore, on the average the ACC performed about 18 percent better than the swirl concentrator. Because similar data are not available on the performance of standard grit removal units, no comparison with such units can be made.

Table 3 also shows the pounds of grit ash per million gallons. This is obtained by dividing the pounds per day of grit ash by the daily flow through the Chastick sampler, based on a flow of 1.38 l/s (21.8 gpm). In all cases there was more grit in the effluent from the swirl degritter than in the effluent from the aerated grit chamber. It should be noted that the flow to the Chastick sampler No. 1 was pumped from the effluent channel of the aerated chamber. The original centrifugal pump used for this purpose tended to plug and it was replaced by a diaphragm pump. After this change it appeared that the surge from the pump might be blowing solids out of the Chastick sampler. Therefore, a surge tank was added ahead of the Chastick sampler. Flow to both Chastick No. 1 and Chastick No. 2 was by gravity so this problem did not occur in these units. It should be noted that although the quantity of grit ash increased from 15.7 to 29.6 kg/1,000 l (131 to 247 lbs/m gal), an increase of 88 percent, the change in the percent removal was considerably less.

Grit ash is used as a measure of efficiency of grit chambers since it represents the inorganic, heavier material that a grit chamber is designed to remove. During certain periods of low flow, organic particles also settle and were present in the samples, however, if the chamber is operated at the design flow rate, organic particles would not be entrapped, and therefore cannot be included in the efficiency calculation.

TABLE 1. PROPOSED TESTS - FIRST SERIES--MAY 15 TO JUNE 11, 1975

Sample Point	Grit Volume	Dry Grit Weight	Total Solids %	Volatile Solids %	Incrementibles %	Sieve Analysis
Channel # 1 Influent	D	D		2W		
Channel # 2 Batch Effluent	D	D		2W		
Channel # 3 ASC Effluent	D	D		2W		
Grit Batch Concentrator Post-Wash	D		C24h	2W	SS	WC
Grit Air-Elutor Classifier Discharge	D		C24h	C24h	SS	WC

Notes:
Run 7 days each at Batch flows of 43.8,87.6 and 131.4l/s (1.0, 2.0 & 3.0 mgd)

D - daily total
2W - average of two samples/week
WC - weekly composite on dry grit (wet added grit)
SS - single sample
C24h - weekly composite of samples taken at 4 hour intervals

(continued)

TABLE 2. (continued)

Sample Point	Suspended Solids mg/l	Volatile Suspended Solids mg/l	BOD mg/l	COD mg/l
Grit Swirl Concentrator Pre-Week	CBA	CBA		
Grit Dorr-Oliver Classifier Influent	CBA	CBA		
Aerated Channel #1 influent	CH2	CH2	CH2	CH2
Swirl Effluent	CH2	CH2		
Aerated Grit Chamber (AGC) # 1 influent	CH2F	CH2F	CH2F	CH2F
Primary influent (AGC effluent)	CH2F	CH2F		

Notes:

CBA - weekly composite of samples at 4 hour intervals

CH2 - weekly composite of 250 ml samples taken at 2 hour intervals

CH2F - weekly composite of flow adjusted samples at 2 hour intervals

TABLE 2. REMOVAL OF GRIT ABS—MAY 23 - JUNE 21, 1975

	Cheetah Sampler	Dry Grit lbs/Day	(Kgs/Day)	Volatile Solids %	Grit Ash lbs/Day	(Kgs/Day)	Removal of Grit Ash % Detri	A.E.C.	Lbs of Grit Ash / Million Gallons	Kgs of Grit Ash / Million Liters
	Flow: Detri - 43.6 l/s (1.0 mgd); AEC - 3029 l/s (69.3 mgd)									
1	Inflow	9.84	(4.5)	54.3	4.13	(1.87)			131	(16)
2	Detri	2.13	(0.97)	53.1	1.85	(0.45)	75.8		31.8	(4)
3	AEC	0.74	(0.34)	58.2	0.30	(0.14)		92.7	9.6	(1.2)
	Flow: Detri - 87.6 l/s (2.0 mgd); AEC - 3177 l/s (69.7 mgd)									
1	Inflow	8.14	(3.7)	38.8	6.45	(2.93)			205	(25)
2	Detri	3.55	(1.6)	41.9	2.06	(0.93)	68.0		65.6	(8)
3	AEC	2.86	(1.3)	70.4	0.85	(0.4)		86.8	27.0	(3.2)
	Flow: Detri - 131.4 l/s (3.0 mgd); AEC - 3247 l/s (69.0 mgd)									
1	Inflow	9.48	(4.3)	17.5	7.76	(3.5)			247	(30)
2	Detri	3.17	(1.44)	61.4	1.22	(0.55)	84.1		38.8	(4.6)
3	AEC	2.33	(1.06)	66.9	0.77	(0.35)		90.0	24.5	(3.0)

Average % removal of grit ash:

Detri	76.0	
AEC		89.8

The removal of dry grit is shown in Table 6. The removals in the swirl concentrator ranged from 56.6 to 78.4 percent, with an average of 66.4 percent. In the aerated grit chamber the removals ranged from 65.9 to 91.8 percent, with an average of 77.3 percent. In all three test runs the percent removal in the aerated grit chamber was better than that accomplished in the swirl degritter.

TABLE 6. REMOVAL OF DRY GRIT
MAY 31-JUNE 21, 1975

1.8m (6 ft) Diameter Swirl Flow	% Removal Dry Grit		% Predicted Swirl Efficiency From Figure 67 (3) for Height/Diameter = 2
	Swirl Degritter	Aerated Grit Chamber	
43.8 l/s (1.0 mgd)	78.4	91.8	97
87.6 l/s (2.0 mgd)	56.6	84.9	78
131.4 l/s (3.0 mgd)	66.3	75.2	71
Average	66.4	77.3	

Table 5 shows the removal of suspended and volatile solids for the test period May 31 - June 21, 1975. Removals of suspended solids ranged from 6.3 to 10.9 percent in the swirl degritter compared to 18.8 to 29.6 percent in the aerated grit chamber. Removals of volatile solids ranged from 3.0 to 9.8 percent in the swirl degritter, compared to 19.0 to 30.0 percent in the aerated grit chamber.

Samples of washed grit were collected at four-hour intervals during each seven-day test run. A sample of this seven-day composite was tested for total suspended solids and volatile suspended solids. These results, while not pertinent to this study, reflect a field test efficiency of the grit washers. Sieve analyses were performed on samples of dried grit collected from the Dorr-Oliver Classifier and the swirl unit elevator-washer from the weekly composites. These indicated the relative size of the grit removed by the two units.

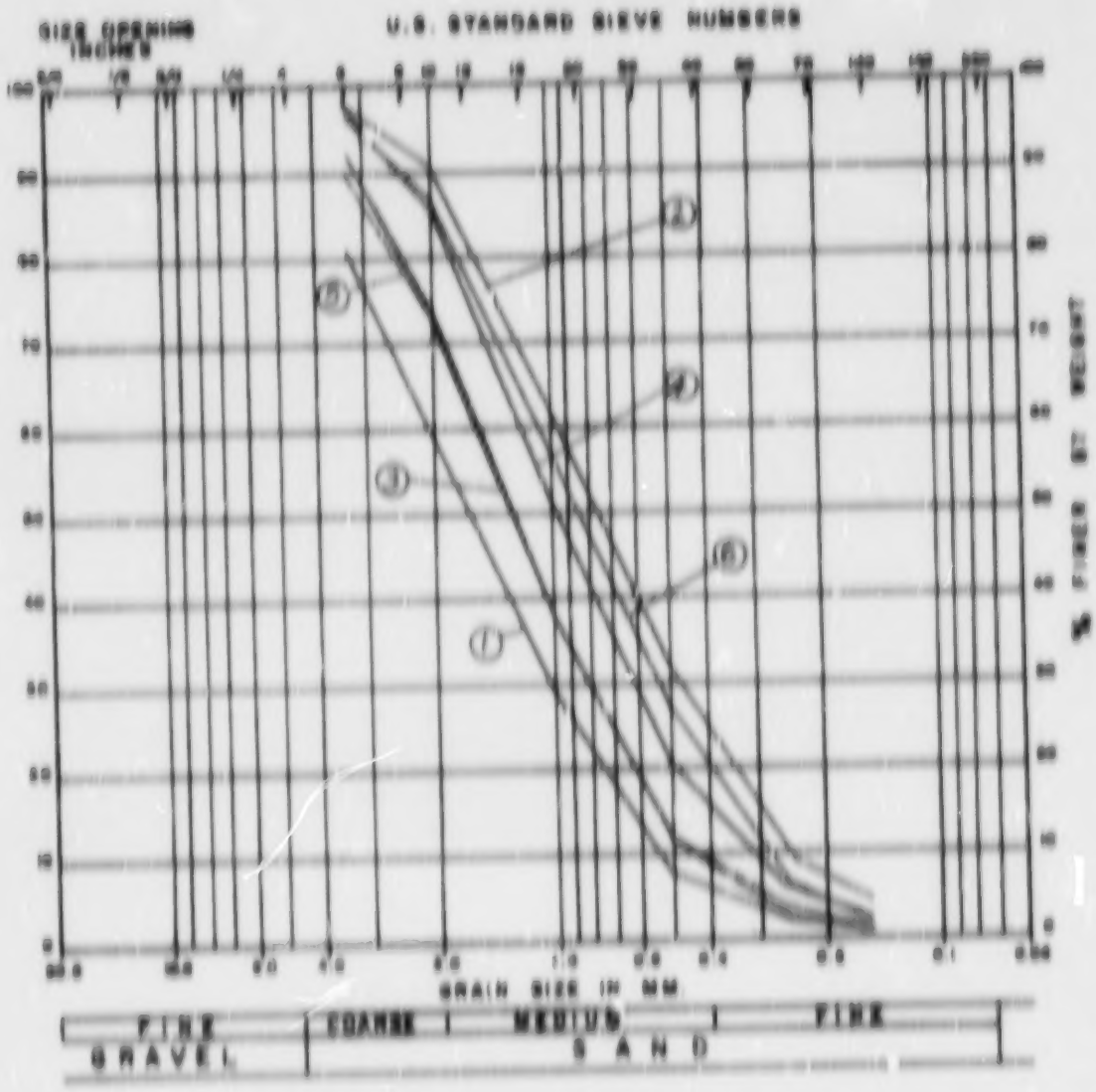
The results are plotted in Figure 7, where the curves indicate the coarsest grit was collected in the swirl degritter when the flow was lowest

TABLE 5

REMOVAL OF SUSPENDED AND VOLATILE SOLIDS
MAY 23 - JUNE 21, 1975

Flow in Swirl	Suspended Solids					
	Swirl Degritter			Aerated Grit Chamber		
	Influent mg/l	Effluent mg/l	% Removal	Influent mg/l	Effluent mg/l	% Removal
43.8 l/s (1.0 mgd)	266	248	6.7	249	184	26.1
87.6 l/s (2.0 mgd)	233	223	4.3	239	194	18.8
131.4 l/s (3.0 mgd)	219	195	10.9	209	147	29.6
AV	239	222	7.1	232	175	24.6

	Volatile Solids					
	Swirl Degritter			Aerated Grit Chamber		
	Influent mg/l	Effluent mg/l	% Removal	Influent mg/l	Effluent mg/l	% Removal
43.8 l/s (1.0 mgd)	199	193	3.0	184	143	22.2
87.6 l/s (2.0 mgd)	184	173	6.0	194	157	19.0
131.4 l/s (3.0 mgd)	173	156	9.8	160	112	30.0
AV	185	174	5.9	179	137	23.5



1 Swirl @ 1 mgd
2 Dorr @ 46.3 mgd
3 Swirl @ 2 mgd
4 Dorr @ 46.7 mgd
5 Swirl @ 3 mgd
6 Dorr @ 49.0 mgd

FIGURE 7 DENVER TESTS GRIT GRADATION CURVES
MAY 23 – JUNE 21 FIRST SERIES

at 43.8 l/s (1.0 mgd). The grit samples from the swirl at the two higher flows showed almost identical gradation curves and indicated coarser grit than that obtained from the aerated grit chamber. It should be noted that the sieve analyses were carried out on dry grit which may have contained considerable large-sized organic matter such as coffee grounds, seeds, corn, and other material. The indication that the aerated grit chamber produces finer grit may be due to the better washing and removal of organic matter performed in the Dorr-Oliver Classifier than was performed by the screw elevator and washer used in conjunction with the swirl concentrator. Therefore, on the next series of tests the sieve analyses were carried out on grit ash from the Chasick sampler. It should also be noted that the recovery of grit of less than 0.2 mm size was 10 percent or less. For this reason it was decided to spike the second series of tests with fine sand.

The second series of test was limited to analyses of the contents of the Chasick samplers. Each test run was limited to two hours and 20 test runs were made with five each at flows in the swirl degritter of 21.9, 43.8, 87.6, and 131.4 l/s (0.5, 1.0, 2.0, and 3.0 mgd). The entire contents of the samplers were collected for each run and tested as described in the Appendix.

The second series investigation is described in Table 6.

To test the effectiveness of the swirl degritter in removing grit of 0.20 mm size, the flow to the swirl unit was spiked by added blasting sand during certain test runs. The spiking material was added just upstream of the discharge point to Chasick sampler No. 1, as shown in Figure 2. About 22.7 kg (50 lb) of sand were added during a one-hour period, beginning about 15 to 30 minutes after the two-hour test run. This quantity of sand, averaged over the two-hour test run, is equivalent to adding 146 gm/m^3, 79 gm/m^3, 36 gm/m^3, and 24 gm/m^3 (1,200, 600, 300, and 200 lbs per mg) for the flows of 21.9 l/s (0.5 mgd), 43.8 l/s (1.0 mgd), 87.6 l/s (2.0 mgd), and 131.4 l/s (3.0 mgd), respectively.

The sieve analysis and gradation curve for the spiking sand is shown in Figure 8.

The second series of tests were run from August 27-30, 1979. The test results are shown in Tables A-4, A-5, A-6, and A-7 of the Appendix.

The efficiency of the swirl chamber in removing dry grit is shown in Table 7.

No removals are shown for the AGU when the flow was spiked, since the spiking only affected the grit collected in Chasick samplers Nos. 1 and 2 and not No. 3. Thus, only 8 of the 20 tests applied to AGU. The results for the AGU ranged from a 51 percent reduction to a 132 percent increase in grit.

This great variation in grit removal in the AGU is difficult to explain since, during the first series of tests, the removals for the seven-day period were 91.8, 64.9, and 75.2 percent, with an average of 77.3 per-

TABLE 6

PROPOSED TESTS SECOND SERIES
AUGUST 27 - 31, 1975

Sample Point		Grit Volume	Dry Grit Weight	Volatile Solids %	Sieve Analysis
Chestck # 1	Inflow	2H	2H	8S	2G
Chestck # 2	Swirl	2H	2H	8S	2G
Chestck # 3	AGC	2H	2H	8S	2G

Note:

Spiking - Spike influent sewage with 0.25 mm sand at rate of 22.7 kg/hr * (50 lb/hr) if Chestck # 1 does not indicate 20% of 0.2 mm grit.

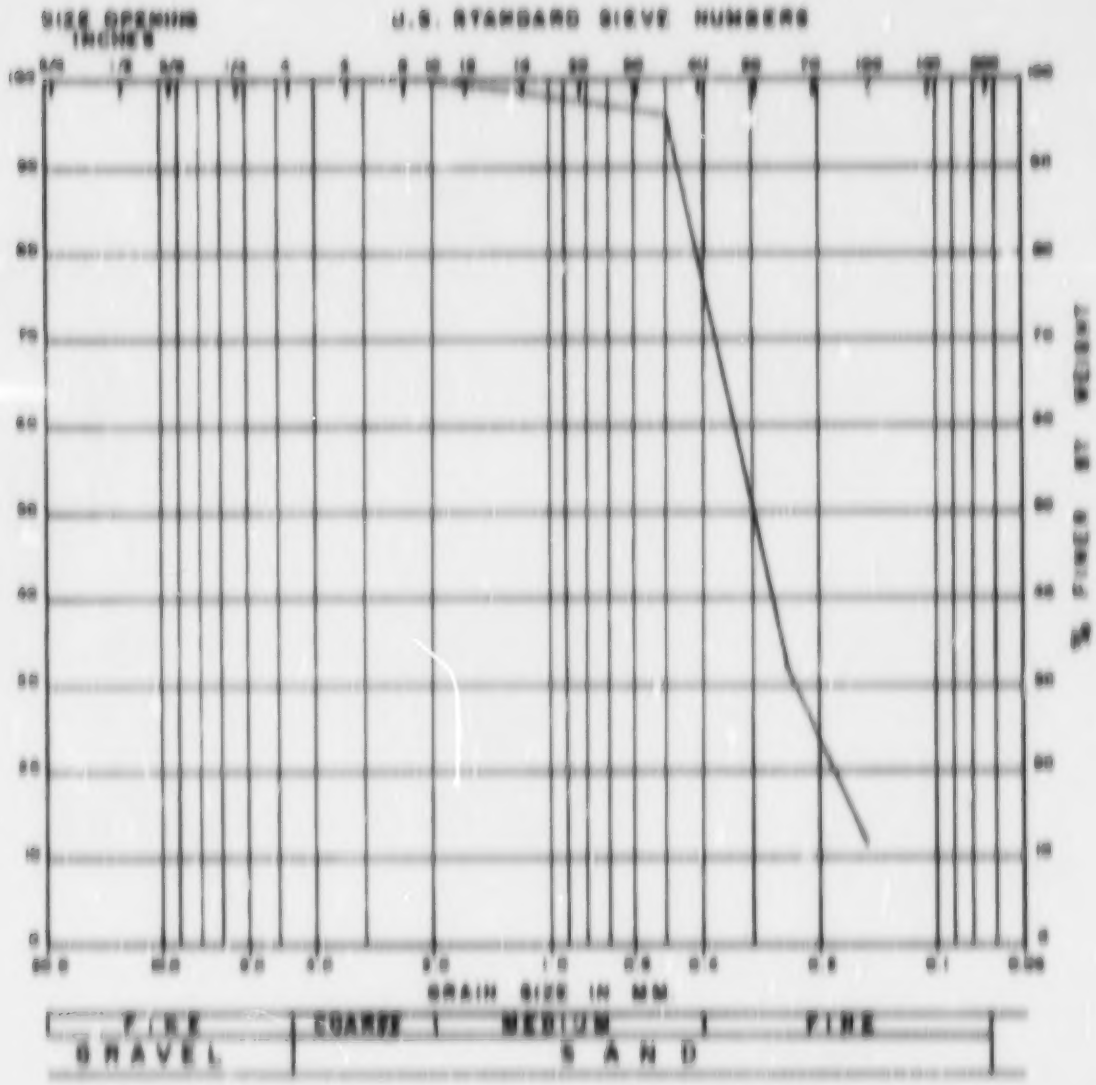
2H Total for two hour tests. Five tests each at flows of 21.9, 43.8, 87.6 and 131.4 l/s (0.5, 1.0, 2.0 and 3.0 mgd) in swirl.

8S Single sample from each two hour test.

2G On incinerated contents of two hour test or aliquot sample if volume too great.

* GRIT CONCENTRATIONS

Flow mgd	lbs/mg	mg/l
0.5	2400	288
1	1200	144
2	600	72
3	400	48



Spike is dry blotting sand, 0.09 mm size.

SIEVE ANALYSIS

U.S. Sieve No.	% Finer by Weight
100	11.4
60	32.0
35	66.3
18	96.9
10	100.0

FIGURE 8 GRADATION CURVE OF SPIKING SAND

TABLE 7. REMOVAL OF DRY GRIT
AUGUST 27-30, 1975

Flow Swirl Degritter	Run Number	Percent Removal		
		Swirl Degritter Normal	Spiked	AOC
21.9 l/s (0.5 mgd)	1	57	64	14
	2			
	3		83	
	4		70	
	5	66	---	+127
	AV	62	72	+ 56
43.8 l/s (1.0 mgd)	1	50		51
	2		87	
	3	79		9
	4		68	
	5	---	77	---
	AV	64	78	30
87.6 l/s (2.0 mgd)	1	26		43
	2		68	
	3		43	
	4		59	
	5	+30	---	+131
	AV	+12	50	+ 44
131.4 l/s (3.0 mgd)	1	8		17
	2		+32	
	3		+46	
	4		41	
	5	46	---	11
	AV	10	+12	14

Note: Percent removed based on dry weight. Flow rate in the AOC was at approximately 2,190 l/s (50 mgd).

cent, as shown in Table 6. Subsequent tests with the AOC at higher flow rates showed a significant reduction in efficiency, as shown in Table 8.

The percent removals of dry grit from the swirl degritter were fairly uniform for flows of 21.9 and 43.8 l/s (0.5 and 1.0 mgd) with removals ranging from 50 to 87 percent. There was no marked difference in the removals at the top flow rates. However, the removals at the two higher flow rates of 87.6 and 131.4 l/s (2.0 and 3.0 mgd) were erratic, with 3 of 10 test runs showing an increase in grit. Here again, the results failed to agree with

TABLE 8

REMOVAL OF GRIT ASH
AUGUST 27, 1975

Swirl Flow 21.9 l/s (0.5 mgd)

Run No.	Chamber Sampler	Grit Ash		%Removal of Grit Ash			lbs per Million Gallons
		gr/hr	lbs/hr	Swirl	AGC	gr/m³	
1	1	104	0.229			21	175
	2	24	0.053	76.8		5	40
	3	19	0.042		8	4	32
2	1	29	0.063			58	48
	2	11	0.024	61.9		2	18
	3	13	0.028		55.6	3	21
3	1	163	0.358			33	274
	2	17	0.037	89.7		3	28
	3	22	0.049		8	4	37
4	1	43	0.093			9	71
	2	9	0.019	79.6		2	14
	3	14	0.031		8	3	24
5	1	15	0.034			3	26
	2	4	0.009	73.5		1	7
	3	15	0.033		2.9	3	25
	Average Spiked			82.0			
	Average Normal			67.7	29.2		

Note:
lbs/mg = lbs/hr x 764

S - Flow Spiked - not applicable

the first series of tests which showed removals of 76.6, 56.6, and 66.3 percent, as reported in Table 6. This may be due to removal by the higher flow of grit deposited in the inlet conduit in previous runs.

The percent removals of dry grit are shown graphically in Figure 9. This figure shows that only at the two lower flows did the swirl degritter perform as well as in the first series of tests. The figure also shows the erratic results obtained in the AGD.

The weight of dry grit collected in the Chastek samplers in the two-hour test runs were converted to grams/m^3 (lbs/mg), based on a constant flow of 1.38 l/s (21.8 gpm) through the samplers. The results are shown graphically in Figure 10. These curves show the effect of spiking on Chastek samplers Nos. 1 and 2. Denver personnel reported that the point of spiking was too close to the outlet point of Chastek sampler No. 1 and hence, the full effect of spiking was not always felt by that sampler. This was most obvious on August 20, 1975 when sampler No. 2 showed more grit in Runs 2 and 3 than sampler No. 1. The figure also shows that the spiking had little effect on sampler No. 3.

During the second series of tests the volatile solids in the various grit samples ranged from 17.2 to 83.0 percent. Therefore, it was thought it might be significant to work up data for the grit ash which would exclude the effect of organic matter on the quantity of grit. These results are shown in Tables 8 through 11. The percent removals are shown graphically in Figure 11. The results are similar to those for removal of dry grit except the large increase in grit for Run 3 on August 27 and August 29, 1975 for Chastek sampler No. 3 have been changed to slight reductions, indicating that the large increase was due to the collection of organic matter. The weight of grit ash is shown graphically in Figure 12. This indicates a weight of grit ash ranging from 2.39 to 55.1 kg/1,000 m^3 (20 to 460 lbs/mg) in the various samplers. The results are similar to those shown for the dry grit except that the weights are less.

In the second series of tests all material collected in the Chastek samplers in each two-hour period was analyzed for volatile solids. Thus, it is possible to compare the weight of volatile solids in the influent to the plant to the volatile solids in the effluent from the swirl concentrator and from the AGD. The ratio of these quantities is shown in Tables 13 through 15.

Table 13 indicates the results with flow of 21.9 l/s (0.5 mgd) in the swirl concentrator and normal daily flow in the AGD. This indicates the volatile solids in the effluent from the swirl has 91 percent of the volatile solids in the influent. Thus 49 percent of the volatile solids were removed with the grit. The data indicates that the effluent from the AGD had produced a volatile solids greater than 100 percent on each of the five two-hour tests. This is no doubt due to sampling methods. The influent sample was taken from the influent channel which was aerated to keep the solids in suspension. The effluent sample was pumped from the effluent channel from the AGD with no aeration. Possibly the pump suction was located near the bottom of the channel where there was greater density of volatile solids.

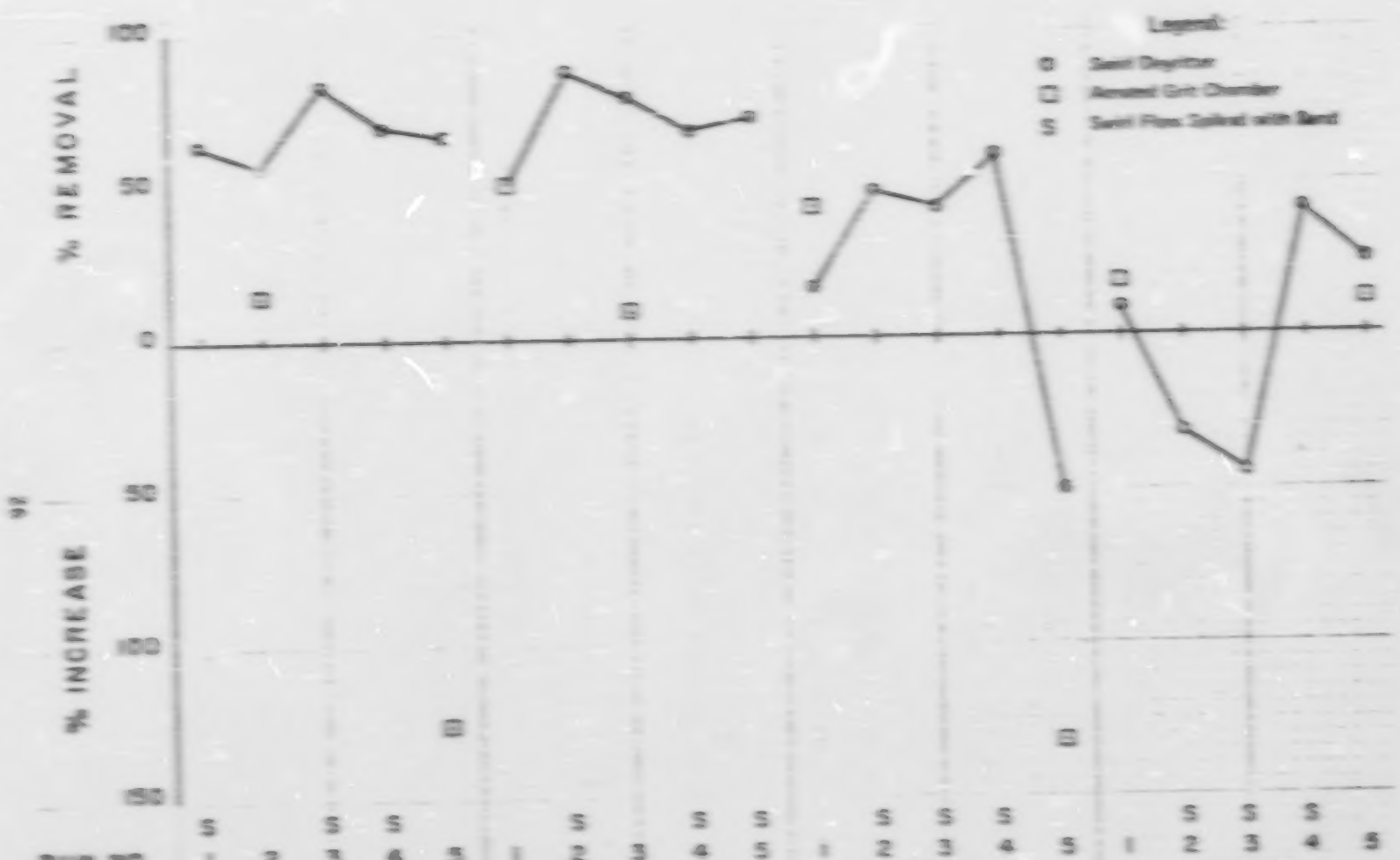


FIGURE 9 REMOVAL OF DRY GRIT – AUGUST 1975

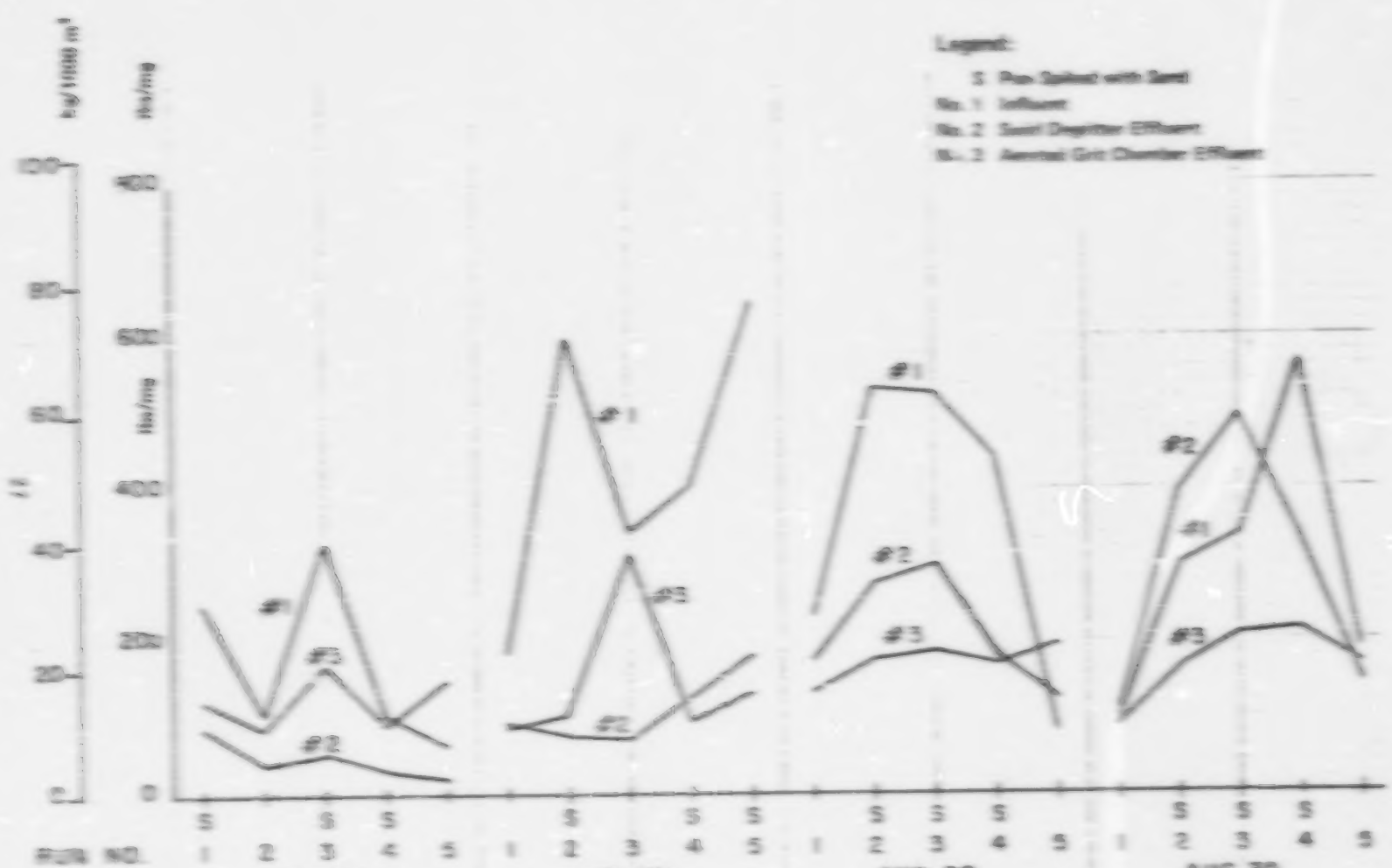

Legend:
S Pea Gravel with Sand
No. 1 Influent
No. 2 Sand Degritter Effluent
No. 3 Aerated Grit Chamber Effluent
#1
#2
#3
RUN NO. 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5
DATE AUG. 27 AUG. 28 AUG. 29 AUG. 30
SWIRL FLOW

FIGURE 18 WEIGHT OF DRY GRIT – AUGUST 1975

TABLE V

REMOVAL OF GRIT ASH
AUGUST 28, 1975

Swirl Flow 63.8 l/s (1.0 mgd)

Run No.	Cheetah Sampler	Grit Ash		Removal of Grit Ash			lbs per Million Gallons
		mg/hr	lbs/hr	Swirl	ACC	mg/m³	
1	1	72	0.159			15	121
	2	30	0.065	58.9		6	50
	3	22	0.048		69.6	4	37
2	1	263	0.580			53	443
	2	28	0.062	89.3		6	47
	3	25	0.056		B	5	43
3	1	114	0.250			23	191
	2	16	0.036	85.6		3	28
	3	81	0.179		28.4	16	137
4	1	166	0.366			34	280
	2	40	0.088	78.0		8	67
	3	26	0.049		B	4	34
5	1	277	0.611			56	467
	2	57	0.126	79.4		12	96
	3	27	0.059		B	5	41
	Average Spiked			81.6			
	Average Normal			78.3	49.0		

Note:
lbs/mg = lbs/hr x 764

B - Flow Spiked - not applicable

TABLE 10

REMOVAL OF GRIT ASH
AUGUST 29, 1975

Swirl Flow 87.6 l/s (2.0 mgd)

Run No.	Sheetick Sampler	Grit Ash		%Removed of Grit Ash			lbs per Million Gallons
		gr/hr	lbs/hr	Swirl	ACC	gr/m^3	
1	1	78	0.171			16	131
	2	47	0.104	39.2		9	79
	3	28	0.062		63.7	6	47
2	1	247	0.543			50	415
	2	102	0.225	58.6		21	172
	3	30	0.067		8	6	51
3	1	248	0.546			49	417
	2	101	0.222	59.3		20	170
	3	32	0.070		8	6	53
4	1	208	0.458			42	350
	2	67	0.147	67.9		13	112
	3	28	0.062		8	6	47
5	1	30	0.065			6	50
	2	23	0.051	21.5		5	39
	3	28	0.062		4.6	6	47
	Average Spiked			61.9			
	Average Normal			30.4	36.2		

Note:
lbs/mg = lbs/hr x 764

S - Flow Spiked - not applicable

TABLE 11

REMOVAL OF GRIT ASH
AUGUST 30, 1975

Spill Flow 13).6 l/s (3.0 mgd)

Run No.	Cheetah Sampler	Grit Ash		Removal of Grit Ash			lbs per Million Gallons
		mg/kg	lbs/hr	Spiki	ASU	mg/m^3	
1	1	28	0.063			6	47
	2	20	0.043	30 6		4	33
	3	17	0.037		40.3	3	28
2	1	121	0.267			24	204
	2	185	0.408	+52.8		37	312
	3	27	0.060		8	6	46
3	1	141	0.311			28	238
	2	238	0.524	+68.5		48	401
	3	44	0.096		8	9	73
4	1	251	0.553			51	423
	2	97	0.213	61.5		20	163
	3	34	0.074		8	7	57
5	1	63	0.138			12	105
	2	33	0.073	47.1		6	56
	3	29	0.063		54.3	6	48
	Average Spiked			419.9			
	Average Normal			38.8	47.3		

Note:
lbs/mg = lbs/hr x 784

S - Flow Spiked - not applicable

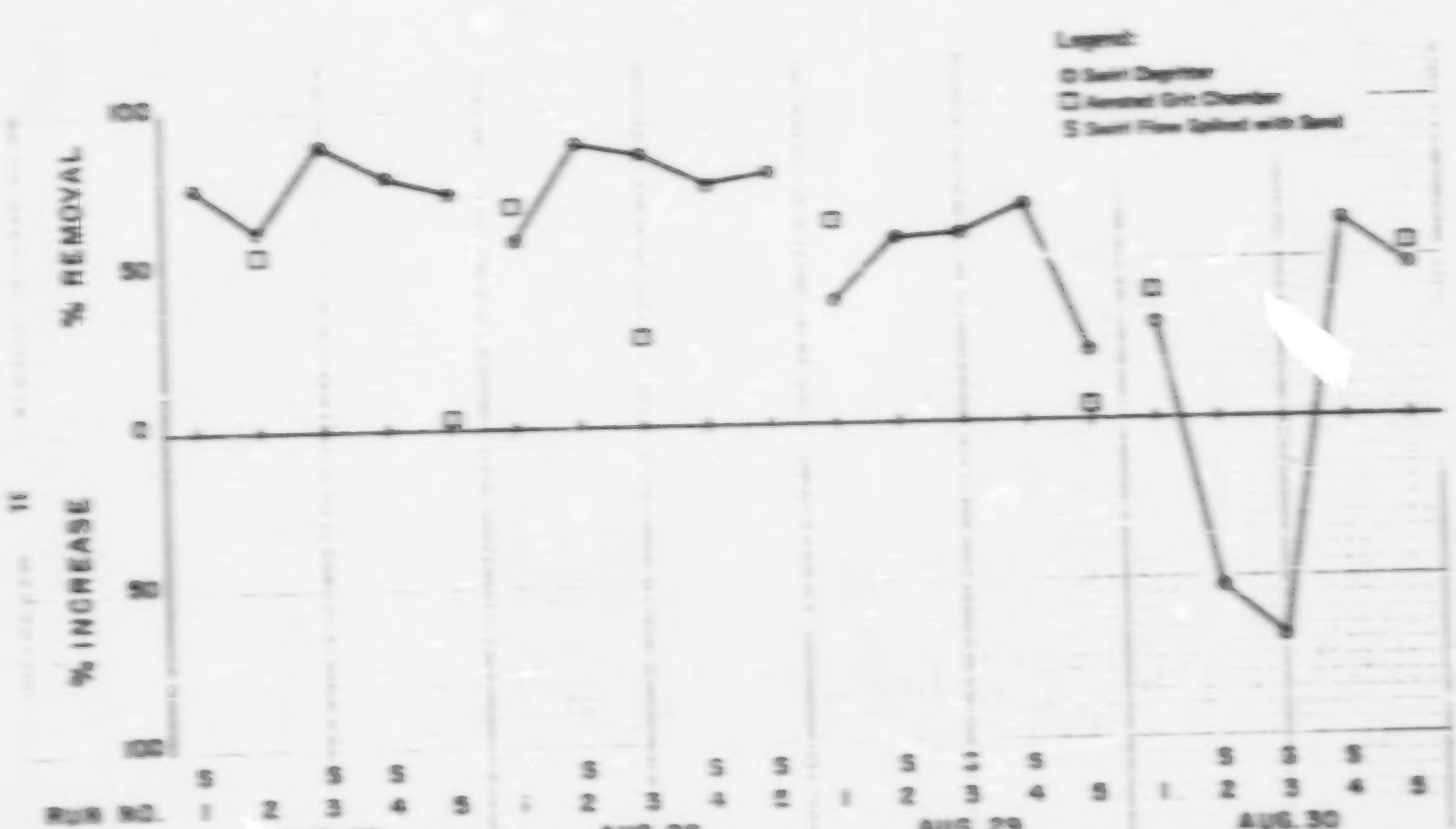


FIGURE 77 REMOVAL OF GRIT ASH – AUGUST 1975

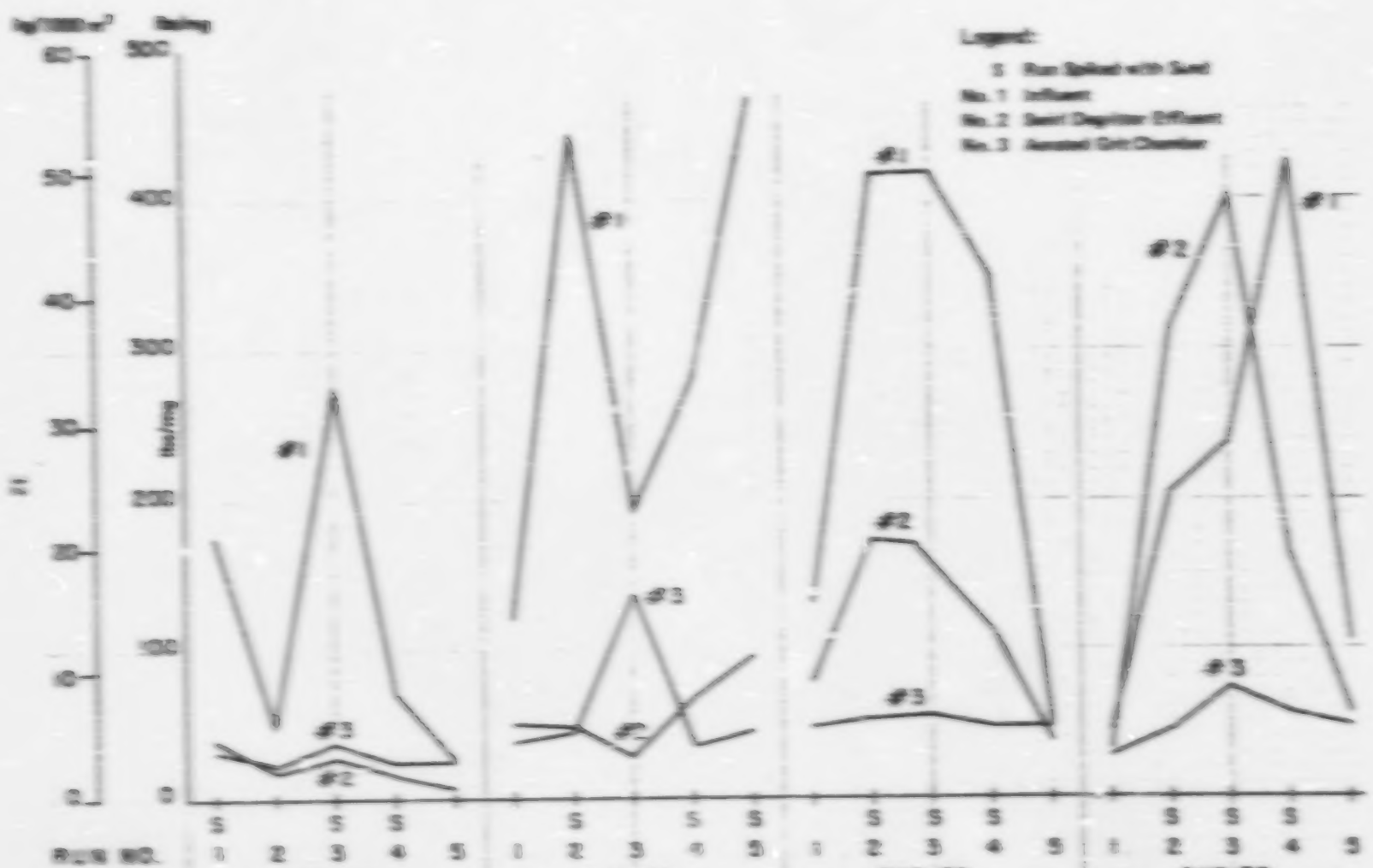

Legend:
S Raw Sidehill with Sand
No. 1 Inflow
No. 2 Sand Depletion Effluent
No. 3 Annular Grit Chamber
#1
#2
#3
RUN NO. 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5
DATE AUG. 27 AUG. 28 AUG. 29 AUG. 30
SWIRL FLOW

FIGURE 12 WEIGHT OF GRIT ASH – AUGUST 1975

TABLE 12

REMOVAL OF VOLATILE SOLIDS
MAY 23 - JUNE 21, 1975

Test No.		Checkick #	Dry Grit lbs/day	Volatile Solids %	Volatile Solids lbs/day	Ratio of Volatile Solids Effluent To Influent Swirl	AGC
	Influent	1	9.04	54.3	4.91		
1	Swirl	2	2.13	53.1	1.13	0.23	
	Effluent	3	0.74	59.2	0.44		0.09
	Influent	1	8.14	20.8	1.69		
2	Swirl	2	3.55	41.9	1.49	0.88	
	Effluent	3	2.86	70.4	2.01		1.19
	Influent	1	9.60	17.1	1.65		
3	Swirl	2	3.17	61.4	1.95	1.18	
	Effluent	3	2.33	66.9	1.56		0.95

Test No.	Flow Swirl		Flow AGC	
1	43.8 l/s	(1.0 mgd)	3028 l/s	(46.3 mgd)
2	87.6 l/s	(2.0 mgd)	3177 l/s	(49.7 mgd)
3	131.4 l/s	(3.0 mgd)	3147 l/s	(49.0 mgd)

TABLE 13

REMOVAL OF VOLATILE SOLIDS
AUGUST 27, 1975

Run		Sheetch #	Dry lb/hr	Volatile Solids %	Volatile Solids lb/hr	Ratio of Volatile Solids Effluent To Influent Swirl	Ratio of Volatile Solids Effluent To Influent AGC
	Influent	1	0.324	39.3	0.095		
1	Swirl	2	0.117	54.5	0.064	0.67	
	Effluent	3	0.169	74.5	0.131		1.37
	Influent	1	0.133	52.6	0.070		
2	Swirl	2	0.057	57.2	0.033	0.47	
	Effluent	3	0.114	75.5	0.086		1.23
	Influent	1	0.432	17.3	0.074		
3	Swirl	2	0.074	49.4	0.037	0.50	
	Effluent	3	0.225	78.2	0.176		2.38
	Influent	1	0.138	32.6	0.045		
4	Swirl	2	0.042	54.7	0.023	0.51	
	Effluent	3	0.116	73.0	0.085		1.89
	Influent	1	0.086	60.9	0.052		
5	Swirl	2	0.029	67.9	0.020	0.38	
	Effluent	3	0.195	83.0	0.162		3.11
					Total	2.53	9.88
					Average	0.51	1.98

Notes:

Swirl Flow 21.9 l/s (0.5 mgd)
AGC = Aerated Grit Chamber

TABLE 14

REMOVAL OF VOLATILE SOLIDS
AUGUST 28, 1975

Run		Chemtech #	Dry lb/hr	Volatile Solids %	Volatile Solids lb/hr	Ratio of Volatile Solids Effluent To Influent Swirl	AGC
	Influent	1	0.242	34.8	0.084		
1	Swirl	2	0.122	46.5	0.057	0.68	
	Effluent	3	0.119	59.4	0.071		0.85
	Influent	1	0.783	25.9	0.203		
2	Swirl	2	0.100	38.3	0.038	0.19	
	Effluent	3	0.140	59.7	0.084		0.41
	Influent	1	0.453	44.9	0.203		
3	Swirl	2	0.095	62.4	0.059	0.29	
	Effluent	3	0.414	56.8	0.235		1.16
	Influent	1	0.531	31.1	0.165		
4	Swirl	2	0.170	48.2	0.082	0.50	
	Effluent	3	0.138	65.0	0.089		0.50
	Influent	1	0.844	27.6	0.233		
5	Swirl	2	0.238	47.2	0.112	0.48	
	Effluent	3	0.174	66.1	0.115		0.50
					Total	2.14	3.43
					Average	0.43	0.68

Notes:

Swirl Flow 43.8 l/s (1.0 mgd)
AGC = Aerated Grit Chamber

TABLE 15

REMOVAL OF VOLATILE SOLIDS
AUGUST 29, 1975

Run		Check #	Dry lb/hr	Volatile Solids %	Volatile Solids lb/hr	Ratio of Volatile Solids Effluent To Influent Swirl	Ratio of Volatile Solids Effluent To Influent AGC
	Influent	1	0.305	43.8	0.134		
1	Swirl	2	0.226	54.0	0.122	6.91	
	Effluent	3	0.175	64.6	0.113		0.84
	Influent	1	0.693	21.6	0.150		
2	Swirl	2	0.361	37.6	0.136	0.91	
	Effluent	3	0.230	70.9	0.163		1.09
	Influent	1	0.686	20.4	0.140		
3	Swirl	2	0.392	43.4	0.170	1.21	
	Effluent	3	0.241	70.8	0.171		1.22
	Influent	1	0.579	20.9	0.121		
4	Swirl	2	0.236	37.9	0.089	0.74	
	Effluent	3	0.221	71.9	0.159		1.31
	Influent	1	0.109	40.5	0.044		
5	Swirl	2	0.164	68.8	0.113	2.57	
	Effluent	3	0.253	75.5	0.191		4.34
					Total	6.34	8.80
					Average	1.27	1.76

Natural

Swirl Flow 87.6 l/s (2.0 mgd)
AGC = Aerated Grit Chamber

TABLE 16

REMOVAL OF VOLATILE SOLIDS
AUGUST 30, 1975

Run		Chgstck #	Dry lb/hr	Volatile Solids %	Volatile Solids #/hr	Ratio of Volatile Solids Effluent To Influent: Swirl	AGC
	Influent	1	0.141	75.9	0.079		
1	Swirl	2	0.139	66.8	0.086	1.09	
	Effluent	3	0.117	68.3	0.080		1.01
	Influent	1	0.393	33.0	0.126		
2	Swirl	2	0.519	21.4	0.111	0.88	
	Effluent	3	0.302	70.1	0.142		1.13
	Influent	1	0.443	29.8	0.132		
3	Swirl	2	0.645	18.7	0.121	0.92	
	Effluent	3	0.271	64.5	0.175		1.33
	Influent	1	0.739	25.2	0.186		
4	Swirl	2	0.436	51.2	0.223	1.20	
	Effluent	3	0.279	73.4	0.205		1.10
	Influent	1	0.248	44.3	0.110		
5	Swirl	2	0.187	60.9	0.114	1.04	
	Effluent	3	0.221	71.4	0.157		1.44
					Total	5.13	6.01
					Average	1.03	1.20

Notes:

Swirl Flow 131.4 l/s (3.0 mgd)
AGC = Aerated Grit Chamber

Table 14 shows the results with flow of 43.8 l/s (1.0 mgd) in the swirl. These results show the average remaining percentage of volatile solids is 43 percent for the swirl and 68 percent for the AGG. Both results appear reasonable.

Table 15 shows the results for flow of 87.6 l/s (2.0 mgd) in the swirl. The remaining percentage of volatile solids is 127 percent for the swirl and 176 percent for the AGG. If the results for Run No. 5 are deleted, the percentages are 96 for the swirl and 111 for the AGG which would be reasonable. Obviously as the flow in the swirl increases the percentage of volatile solids retained in the swirl decreases.

Table 16 shows the results with a flow of 131.4 l/s (3.0 mgd) in the swirl. The remaining percentage of volatile solids are 103 percent in the swirl and 120 percent in the AGG. These results appear reasonable if allowance is made for sampling errors.

The foregoing would indicate that at flows up to 43.8 l/s (3.0 mgd) up to 50 percent of the volatile solids will be removed by the swirl concentrator. Therefore the grit removal mechanism must be selected so that the grit will be thoroughly washed and the wash water returned to the swirl concentrator effluent channel. At flows of 87.6 l/s (2.0 mgd) and greater all the volatile solids appear to pass through the swirl concentrator. The above results are considered reliable because flow from the influent and effluent channels to the Chesick sampler was by the gravity in both cases.

The results for the AGG are not considered reliable because the sample from the effluent channel to Chesick sampler No. 3 was pumped. Possibly the pump intake line was located near the bottom of the channel where the density of volatile solids were greater. Aeration was not provided at this sampling point as was at the point in influent channel from which the influent sample was pumped.

After ignition of the dry grit for determination of volatile solids, the ashed grit in its entirety was sieve-analysed. The data from the sieve analyses are shown in Tables A-6 through A-7 in the Appendix. The sieve analyses for the three grit samples from each test run are shown graphically on Figures 13 through 32. These gradation curves are discussed below for each of the 6 flows through the swirl degritter.

A. Gradation curves for a swirl flow of 21.9 l/s (0.5 mgd):

- With spiking--Figures 13, 15 and 16. These figures are similar. Due to spiking with fine sand, the grit in the influent is finer than the grit from the AGG which did not receive spiking sand. The grit from the swirl concentrator is as in the case without spiking, finer than that in the spiked plant influent.

- Without spiking--Figures 14 and 17. These 2 figures are similar. They indicate that influent grit is coarsest, AGG is medium-sized, and the swirl grit is finest.

Hence, the swirl was removing more of the larger size grit than the AGGs.

B. Gradation curves for swirl flow of 43.8 l/s (1.0 mgd):

- Without spiking--Figures 18 and 20. The swirl grit is coarser than in Figures 14 and 17 and is still finer than the AGC grit. The influent and AGC grit vary considerably between Figures 18 and 20. In Figure 20 the 2 have similar gradation whereas in Figure 18 the influent grit is much coarser and the grit chamber is much finer.

- With spiking--Figures 19, 21 and 22. These curves show the effect of spiking on the influent grit which is finer than without spiking. However, the swirl grit remains about the same as without spiking. The AGC is about the same in Figure 22 as in Figure 18 and is finer than the influent grit. In Figures 19 and 21 the AGC is coarser than in Figure 22 and is coarser than influent grit.

C. Gradation curves for swirl flow of 87.6 l/s (2.0 mgd):

- Without spiking--Figures 23 and 27. These curves show a definite change from Figure 18. The gradation for the influent grit and the AGC is similar to Figure 18. However, in both Figures 23 and 27 the gradation of the swirl grit is not greatly different from the influent grit and the grit from the grit chamber is the finest grit. This would indicate that at some point between a flow of 43.8 l/s (1.0 mgd) and 87.6 l/s (2.0 mgd) the swirl degritter ceases to produce a grit as fine as that from the AGC.

- With spiking--Figures 24, 25 and 26. Figures 25 and 26 exhibit influent grit similar to Figureas 23 and 27 which are without spiking. The laboratory personnel at Denver felt that sometimes during the tests the point of spiking was too close to the inlet to Chastch sampler No. 1 to impose the full effect of the spiking on that sampler. This condition seemed to prevail in Figures 25 and 26. The grit from the swirl is finer than the grit from the AGC, indicating that the spiking may have less effect on the influent as the swirl.

D. Gradation curves for swirl flow of 131.4 l/s (3.0 mgd):

- Without spiking--Figures 28 and 32. These curves indicate that the swirl grit is about the same as, or a little finer than, the influent grit and in both cases much coarser than the AGC grit shown in Figures 23 and 27.

- With spiking--Figures 29, 30 and 31. Figures 29 and 30

are the same for influent and swirl grit, both showing the effect of spiking and both indicating the same gradation. For some reason, the AGO grit is much coarser than the other grit in Figure 30 and much finer than the other grit in Figure 29. In Figure 31 the AGO grit lies between the 2 gradation curves shown in Figures 29 and 30.

In summary, the grit from the swirl is finer than the AGO grit for flows through the swirl of 21.9 l/s (0.5 mgd) and 43.8 l/s (1.0 mgd). At swirl flow of 87.6 l/s (2.0 mgd), without spiking, the swirl grit gradation is about the same as influent grit and coarser than AGO grit. With spiked flow, the same holds true for 2 out of 3 runs.

At a swirl flow of 131.4 l/s (3.0 mgd) for unspiked influent the gradation of the influent grit and the swirl grit is similar but coarser than the AGO grit. For spiked flow, the swirl and influent grit have the same gradation in all three cases. Compared to the AGO grit the swirl and influent grit is finer in one case and coarser in another.

While the swirl degritter results overall were lower than predicted by the LaSalle model hydraulic tests for the higher flow rates of 87.6 l/s (2.0 mgd) and 131.4 l/s (3.0 mgd), at an average flow of 43.8 l/s (1.0 mgd) the results were good. It was suspected that the AGO, like the swirl unit, also would not operate at rated efficiencies for the high rates of flow of 2 and 3 times average flow. These tests were conducted on April 29 and 30, 1976, and were restricted to measuring the efficiency of the AGO only, using Chesich samplers Nos. 1 and 3 as shown in Figure 2. The actual data is presented in Table A-8.

The efficiencies were calculated only for those runs where applicable, and are presented in Table 17. Where the volume of grit in the effluent exceeds the volume of the influent, no efficiency figure is reported. Only in the last two runs does the data show a removal of the grit by the AGO. It is obvious from these data that there is a significant reduction in grit removal when flows exceed design limits regardless of the grit removal method used.

ESTIMATED COSTS

General

For comparative purposes estimates were made of construction and annual operation costs of the swirl concentrator as a grit separator and the standard aerated grit chamber. Estimates were made for three sizes of each type for average flows of 43.8, 131.4 and 438 l/s (1, 3 and 10 mgd). Present worth was determined for each size and type based on a 20-year period and 6-1/8 percent interest rate.

Swirl Degritter

The size of the swirl concentrator was based on data given in the

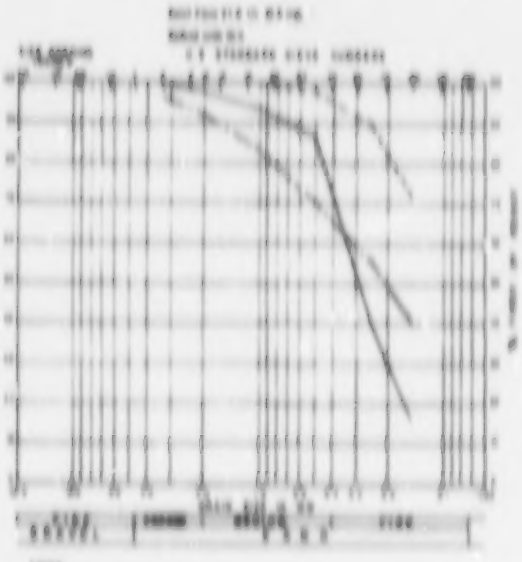


FIGURE 13 GRIT GRADATION CURVES – RUN NO. 1 AUGUST 27, 1975

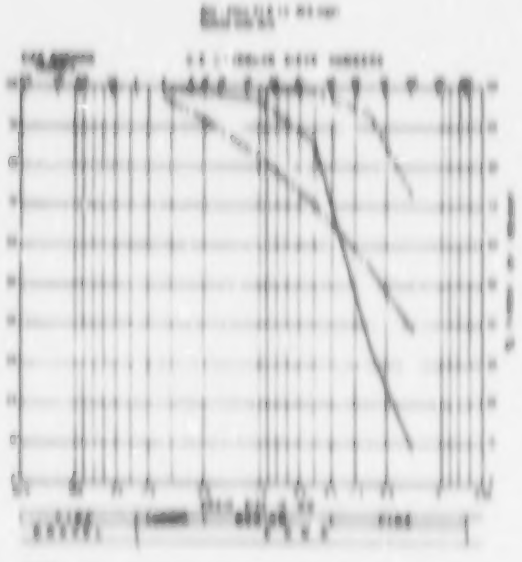


FIGURE 15 GRIT GRADATION CURVES RUN NO. 3 AUGUST 27, 1975

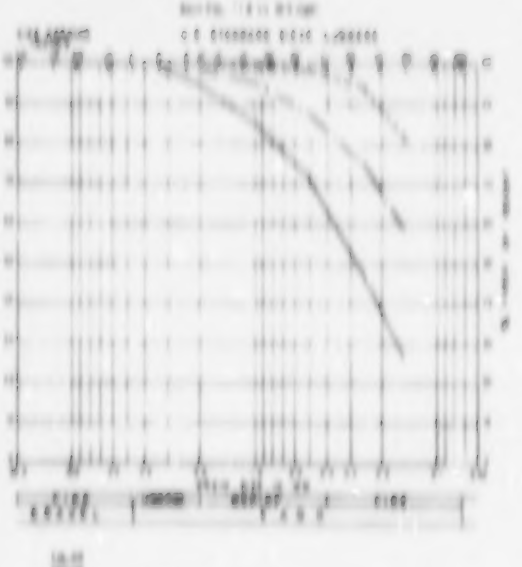


FIGURE 14 GRIT GRADATION CURVES RUN NO. 2 AUGUST 27, 1975

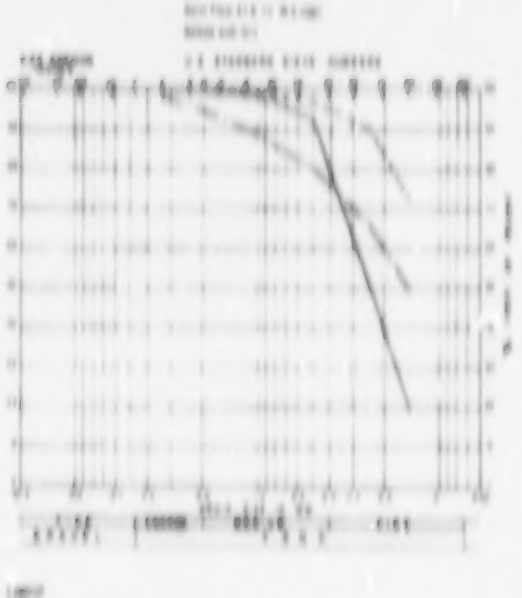


FIGURE 16 GRIT GRADATION CURVES RUN NO. 4 AUGUST 27, 1975

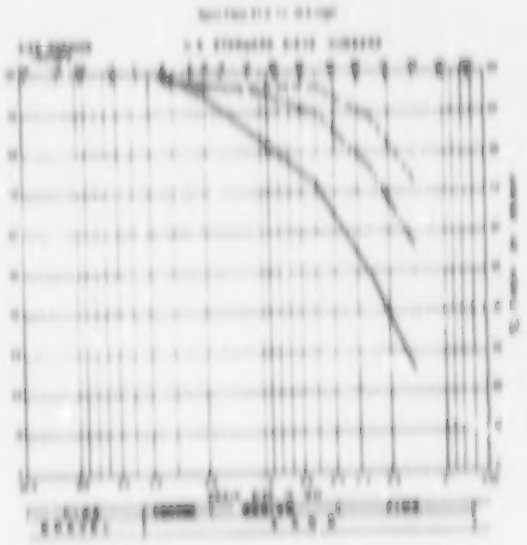


FIGURE 17 GRIT GRADATION CURVES
RUN NO. 5 AUGUST 27, 1975

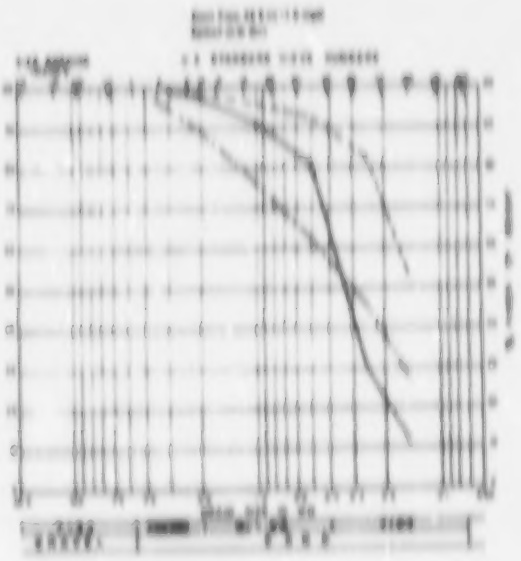


FIGURE 19 GRIT GRADATION CURVES
RUN NO. 2 AUGUST 28, 1975

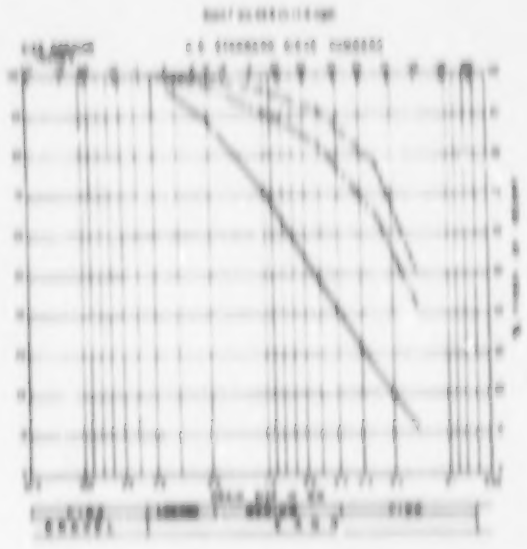


FIGURE 18 GRIT GRADATION CURVES
RUN NO. 1 AUGUST 28, 1975

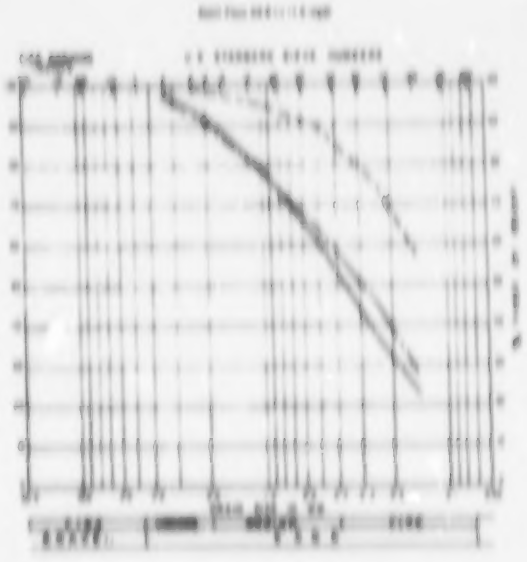


FIGURE 20 GRIT GRADATION CURVES
RUN NO. 3 AUGUST 28, 1975

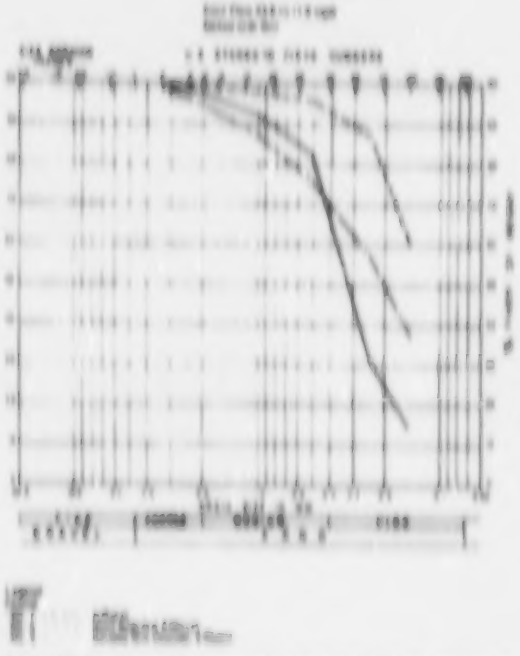


FIGURE 21 GRIT GRADATION CURVES
RUN NO. 4 AUGUST 28, 1975

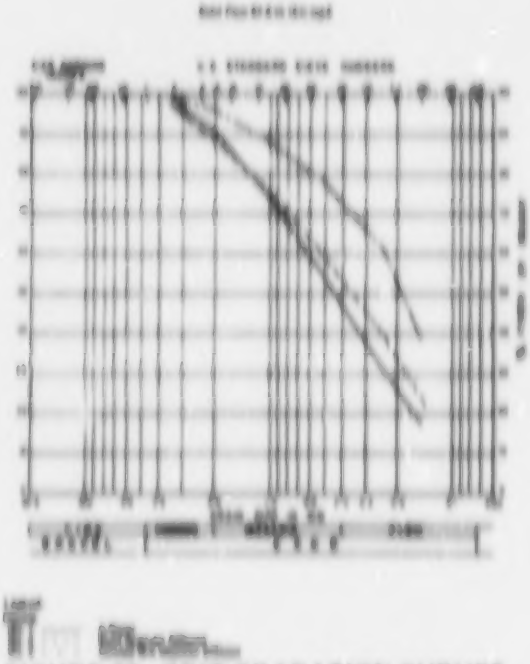


FIGURE 23 GRIT GRADATION CURVES
RUN NO. 1 AUGUST 28, 1975

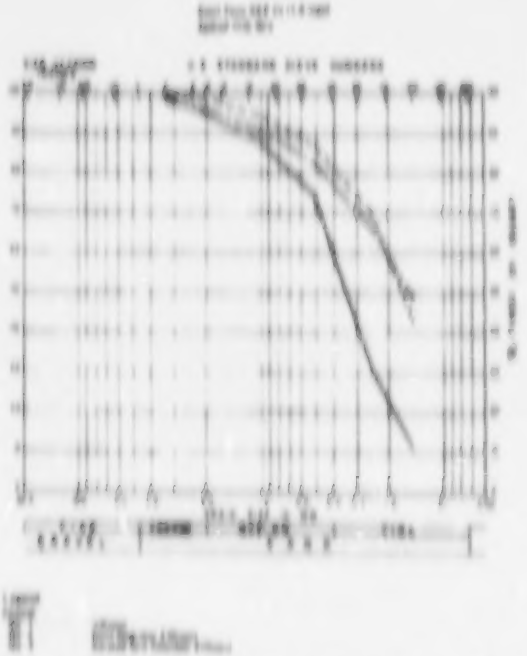


FIGURE 22 GRIT GRADATION CURVES
RUN NO. 5 AUGUST 28, 1975

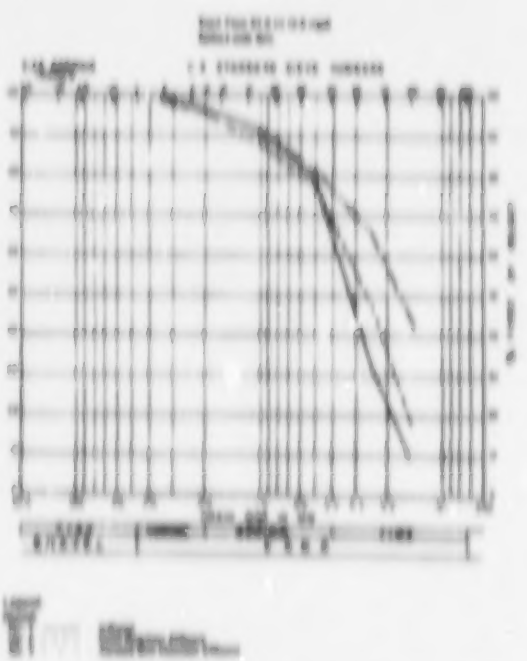


FIGURE 24 GRIT GRADATION CU' /ES
RUN NO. 2 AUGUST 2 1975

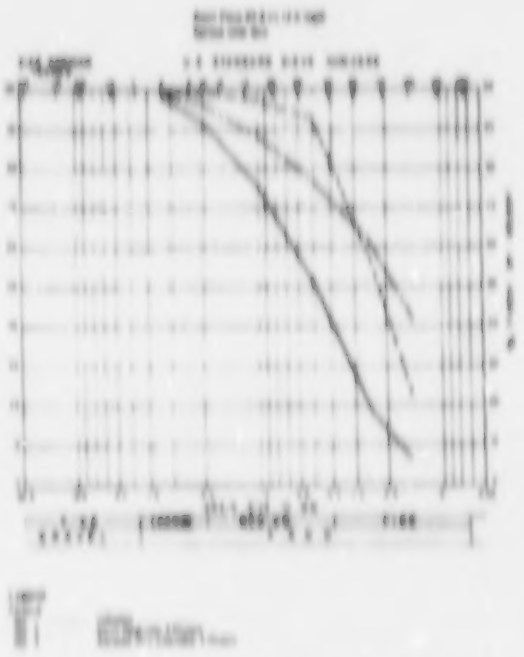


FIGURE 26 GRIT GRADATION CURVES
RUN NO. 3 AUGUST 29, 1975

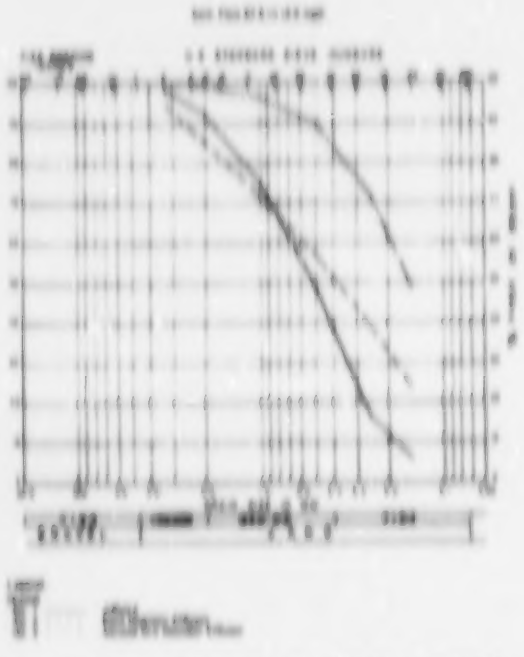


FIGURE 27 GRIT GRADATION CURVES
RUN NO. 5 AUGUST 29, 1975

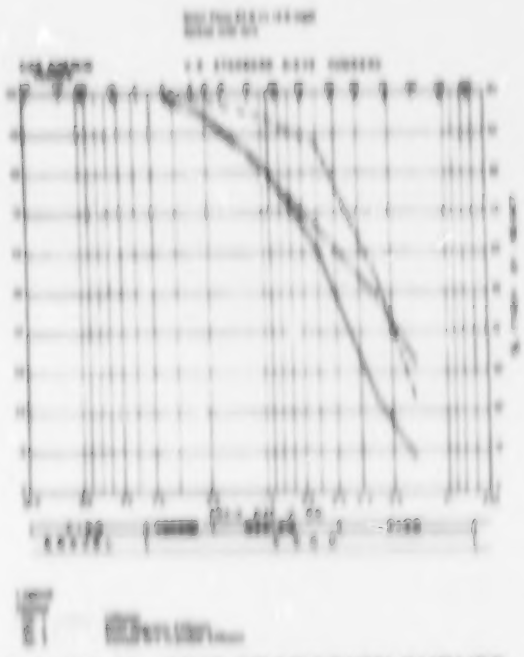


FIGURE 28 GRIT GRADATION CURVES
RUN NO. 4 AUGUST 29, 1975

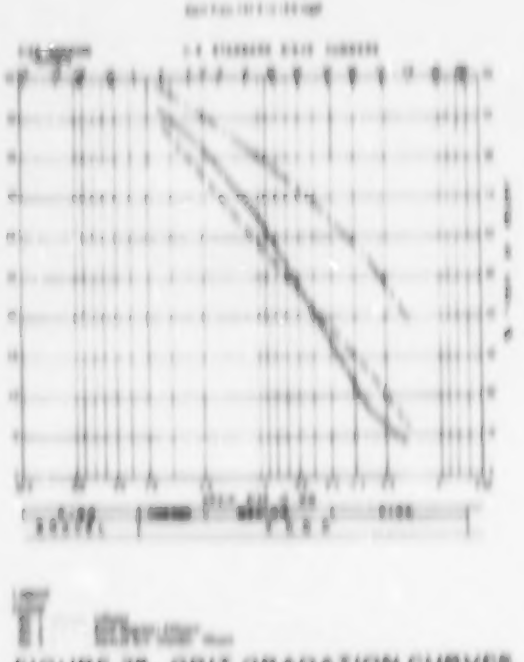


FIGURE 29 GRIT GRADATION CURVES
RUN NO. 1 AUGUST 30, 1975

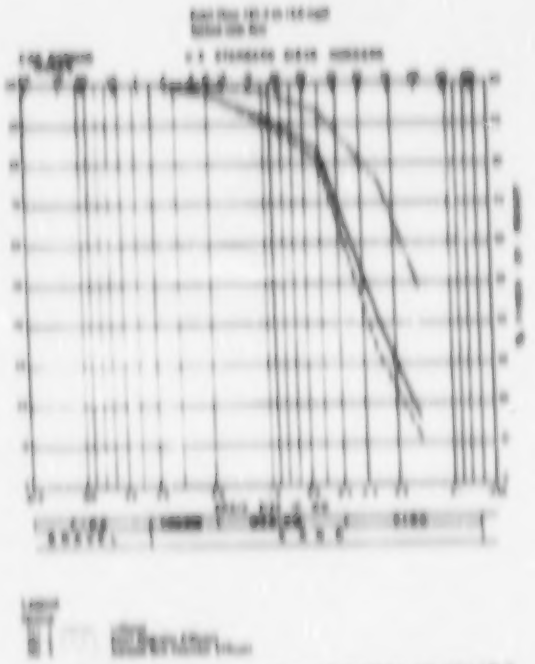


FIGURE 29 GRIT GRADATION CURVES
RUN NO. 2 AUGUST 30, 1976

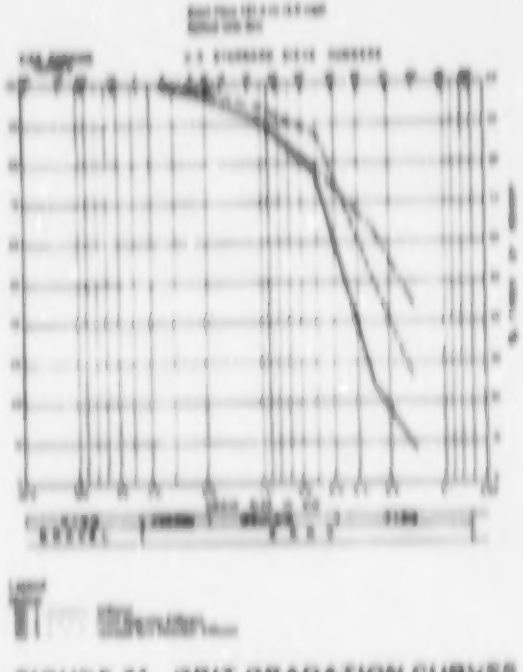


FIGURE 31 GRIT GRADATION CURVES
RUN NO. 4 AUGUST 30, 1976

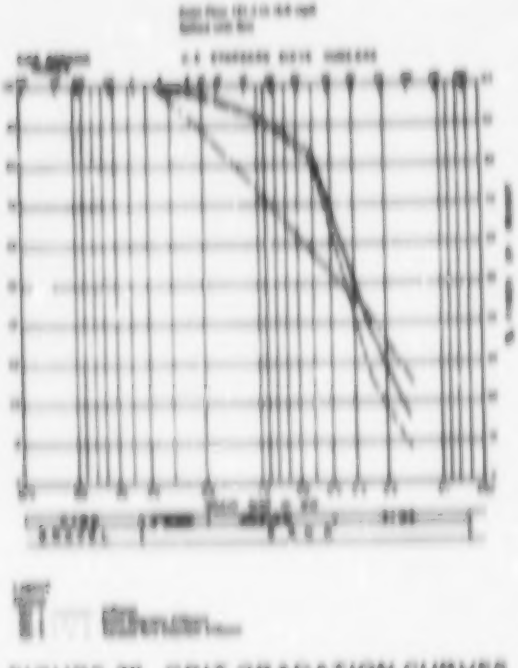


FIGURE 30 GRIT GRADATION CURVES
RUN NO. 3 AUGUST 30, 1976

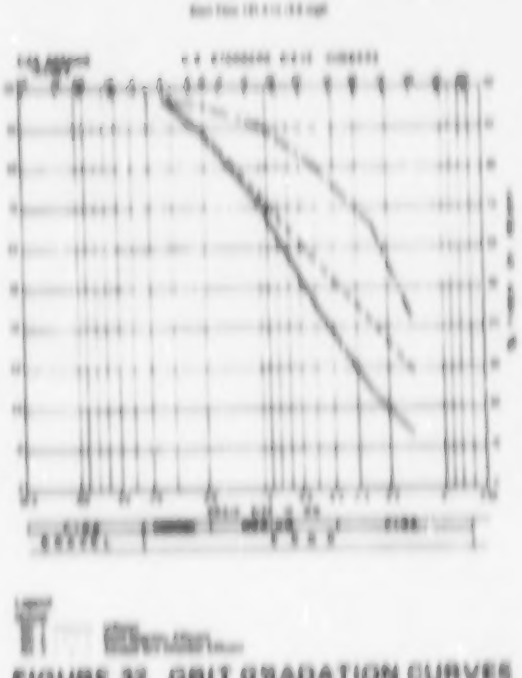


FIGURE 32 GRIT GRADATION CURVES
RUN NO. 5 AUGUST 30, 1976

TABLE 17

AERATED GRIT CHAMBER
SINGLE CHAMBER HIGH FLOW EFFICIENCY

Date	Time	Total Add Flow mgd	Influent Sampler # 1 Flow gpm	Grit Volume Quarts	Effluent Sampler # 1 Flow gpm	Grit Volume Quarts	Efficiency %
4/28/76	7:30 am	35	21.8	2.25	21.8	2.5	—
	9:30 am	58	21.8		21.8		
	10:30 am	70	21.8		21.8		
	12:30 pm	69	21.8	2.0	21.8	2.25	—
4/29/76	8:00 am	22.3	21.8		21.8		
	9:00 am	36.5	21.8		21.8		
	10:00 am	62	21.8	2.0	21.8	2.0	—
	11:00 am	61	21.8		21.8		
	12:00 am	65	21.8	1.75		1.5	8.7
4/30/76	8:00 am	23.5	21.8		21.8		
	9:00 am	46	21.8	2.0	21.8	1.75	18.5

Swirl Concentrator as a Grit Separator Device (2). The principal diameter of the chamber, D_2 was obtained from Figure 13, Chamber Diameters for 90 Percent Recovery and $H_1/D_1 = 2$ (2), using a ratio of H_1 to D_2 of 0.333. The remaining dimensions were obtained from Figure 3, General Design Dimensions (2). The derived dimensions are as follows:

Average Flow	43.8 l/s (1 mgd)	131.4 l/s (3 mgd)	438 l/s (10 mgd)
D_2	1.83 m (6.0 ft)	2.44 m (8.0 ft)	4.27 m (14.0 ft)
D_1 & D_4	0.30 m (1.0 ft)	0.40 m (1.33 ft)	0.71 m (2.33 ft)
D_3	1.22 m (4.0 ft)	1.62 m (5.33 ft)	1.62 m (4.67 ft)
H_1	0.61 m (2.0 ft)	0.81 m (2.67 ft)	1.62 m (4.67 ft)
H_2	0.08 m (0.025 ft)	0.10 m (0.33 ft)	0.17 m (0.58 ft)
H_3 min	0.30 m (1.0 ft)	0.40 m (1.33 ft)	0.61 m (2.0 ft)

The type unit used for estimate purposes was similar to that shown in Figure 9, Grit Chamber Below Ground with Inclined Screw Conveyor (2) with following revisions: (1) the exterior wall of the grit separator was assumed to be of concrete with a vertical exterior face, (2) a horizontal passage through the concrete assumed to provide access for lubricating the bottom fitting of the inclined screw conveyor and (3) a manhole, 0.91 m (3.0 ft) square, was provided to give access to the bottom fitting of the screw conveyor.

Aerated Grit Chamber

The aerated grit chamber was sized to provide a detention period of 3 minutes at the maximum rate of flow. Peak flow factors were based on Figure 4 in American Society Civil Engineers Manual No. 37 (4). The resultant dimensions are as follows:

Average Flow	43.8 l/s (1 mgd)	131.4 l/s (3 mgd)	438 l/s (10 mgd)
Peak flow factor	3.0	2.5	2.0
Maximum flow	131.4 l/s (3 mgd)	328.5 l/s (7.5 mgd)	876 l/s (20.0 mgd)
Required volume	23.6 cu m (835 cf)	59.2 cu m (2090 cf)	157.9 cu m (5,560 cf)

Selected depth	2.44 m (8.0 ft)	3.05 m (10.0 ft)	3.66 m (12.0 ft)
Selected width	2.29 m (7.5 ft)	3.05 m (10.0 ft)	4.27 m (14.0 ft)
Selected length	4.27 m (14.0 ft)	6.41 m (21.0 ft)	10.06 m (33.0 ft)
Selected volume	23.63 cu m (835 cf)	59.08 cu m (2085 cf)	157.09 cu m (5,566 cf)

Construction Costs

Cost estimates of the swirl concentrator as a grit separator device were made for two purposes: (1) to indicate the probable construction cost of the facility; and (2) to compare its cost with that of a conventional aerated grit chamber.

The cost estimates are considered to be reasonable engineer's estimates However, during periods of economic inflation, it is not unusual for contractor's bids to materially exceed engineers' estimates.

Cost Basis

The costs are based on the following:

a. Engineering News Record Construction Cost Index average for U.S. is 2,500

b. Unit prices as follows:

Steel Sheet Piling (for temporary use during construction)	$108/sq m	$10/ sq ft
Excavation	$ 18/cu m	$14/cy
Reinforced Concrete	$392/cu m	$300/cy

c. Contingent and engineering costs are assumed to be 35 percent of the foregoing items.

The swirl separator dimensions are derived in the previous section. It is assumed that the ground surface is 0.61 m (2 ft) above the crown of the inlet pipe and the top of tank is 0.30 m (1 ft) above the crown of the inlet pipe, this will provide 0.61 m (2 ft) of freeboard above the weir.

The conventional aerated grit chamber is set to provide a freeboard 0.46 m (1.5 ft) with a top of wall 0.30 m (1 ft) above ground surface.

The following assumptions are made for both structures:

a. Excavation is all earth. The unit price includes cost for backfilling and crushed stone under the structures.

b. Temporary steel sheet piling is required 0.61 m (2 ft) outside the exterior walls of the structures. Sheeting assumed to extend 0.61 m (2 ft) below lowest point of excavation and 0.30 m (1 ft) above the existing ground elevation.

c. Equipment costs for the aerated grit chamber include the cost of bucket elevator, screw conveyor, transverse baffle, diffuser piping, motors, and electrical work.

d. Miscellaneous costs for the aerated grit chamber include the cost of the longitudinal and effluent baffles, compressors, slide gates, baffle supports, and grating for by-pass channel.

e. Equipment costs for the swirl concentrator include the cost of a grit wash screw.

f. Miscellaneous costs for the swirl separator includes the cost of piping skirt, weirs and plates.

Cost of Swirl Separator as a Grit Separator

The estimated construction cost of a swirl separator with a capacity of 43.8 l/s (1.0 mgd) is $47,000, for 131.4 l/s (3.0 mgd), $57,000, and for 438 l/s (10.0 mgd), $69,000. The breakdown of these costs is shown in Table 18.

Cost of Conventional Aerated Grit Chamber

The estimated construction costs of a conventional aerated grit chamber with a capacity of 43.8 l/s (1.0 mgd) is $69,885, for 131.4 l/s (3.0 mgd) $89,775, and for a 438 l/s (10.0 mgd), $154,965, as seen in Table 19.

Operation and Maintenance Costs

The estimated operation and maintenance costs for the swirl separator and the aerated grit chamber for capacities of 43.8 l/s (1.0 mgd), 131.4 l/s (3.0 mgd) and 438 l/s (10.0 mgd) are shown in Table 20. For units with capacity of 43.8 l/s (1.0 mgd) the annual expenses are estimated at $4,910 for the aerated chamber and $4,450 for the swirl separator. For capacity of 131.4 l/s (3.0 mgd) the annual expenses are $8,300 for the aerated chamber and $7,430 for the swirl separator. For capacity of 438 l/s (10.0 mgd) the annual expenses are $19,760 for the aerated chamber and $13,250 for the swirl separator.

The operator labor is assumed to be 1.5 hours per day for the 131.4 l/s (3.0 mgd) unit. This assumes 1.0 hours for operation of the equipment and 0.5 hours for disposal of the grit. This is based on the actual experience at a unit with the capacity where the daily operation ranges from 0.5 to 1.0 hours with occasional periods of 1.5 hours following storm periods.

TABLE 18 CONSTRUCTION COST OF SWIRL CONCENTRATOR AS A GRIT SEPARATOR

Capacity 43.8 l/s (1.0 mgd)

ITEM	QUANTITY	AMOUNT
Sheet piling	60 sq m (650 sq ft)	$ 6,500
Excavation	95 cu m (125 cy)	1,750
Reinforced Concrete	10 cu m (13 cy)	1,900
Equipment	Job	16,800
Miscellaneous and Bypass	Job	7,400
SUBTOTAL		$36,350
Contingent and Engineering Costs	35%	12,650
TOTAL		$49,000

Capacity 131.6 l/s (3.0 mgd)

Sheet Piling	70 sq m (750 sq ft)	$ 7,500
Excavation	110 cu m (145 cy)	2,030
Reinforced Concrete	12 cu m (15 cy)	4,900
Equipment	Job	19,200
Miscellaneous and Bypass	Job	8,600
SUB TOTAL		$41,830
Contingent and Engineering Costs	35%	15,170
TOTAL		$57,000

Capacity 438 l/s (10.0 mgd)

Sheet Piling	100 sq m (1000 sq ft)	$10,000
Excavation	150 cu m (195 cy)	2,730
Reinforced Concrete	16 cu m (21 cy)	6,300
Equipment	Job	22,000
Miscellaneous and Bypass	Job	10,000
SUBTOTAL		$51,030
Contingent and Engineering Costs	35%	17,860
TOTAL		$68,890

TABLE 19 CONSTRUCTION COST OF CONVENTIONAL AERATED GRIT CHAMBER

Capacity 43.8 l/s (1.0 mgd)

ITEM	QUANTITY	AMOUNT
Sheet Piling	67.5 sq m (725 sq ft)	$ 7,250
Excavation	78 cu m (101 cy)	1,415
Reinforced Concrete	11 cu m (14 cy)	4,200
Equipment	Job	30,800
Miscellaneous	Job	8,100
SUB TOTAL		$51,765
Contingent and Engineering Costs	35%	18,120
TOTAL		$69,885

Capacity 131.4 l/s (3.0 mgd)

Sheet Piling	98 sq m (1060 sq ft)	$10,660
Excavation	cu m (137 cy)	3,385
Reinforced Concrete	cu m (37 cy)	7,200
Equipment	Job	36,400
Miscellaneous	Job	9,900
SUBTOTAL		$66,485
Contingent and Engineering Costs	35%	23,270
TOTAL		$89,775

Capacity 438 l/s (10.0 mgd)

Sheet Piling	157 sq m (1710 sq ft)	$17,100
Excavation	276 cu m (361 cy)	9,054
Reinforced Concrete	34.2 cu m (44.7 cy)	13,410
Equipment	Job	45,000
Miscellaneous	Job	12,000
SUBTOTAL		$96,565
Contingent and Engineering Costs	35%	33,600
TOTAL		$124,965

The labor rate used of $7.00 per hour is intended to include the actual labor cost plus all benefits but excludes administration and general expenses of the overall plant.

Based on the results shown in Table 20, the annual operation costs of the aerated grit chamber will exceed the annual costs of the swirl separator by about 10 percent for each size unit.

Present Worth

The present worth of the grit removal units is shown in Table 21. The present worth is based on a life of 20 years and an interest rate of 6-1/8 percent. Hence the present worth of the operation and maintenance costs for a 20-year period is 11.35 times the annual cost.

For the unit with capacity of 43.8 l/s (1.0 mgd) the present worth of the aerated chamber is $125,885 and the swirl separator is $100,000. Thus the present worth of the aerated chamber is 26 percent greater than that of the swirl separator.

For the unit with capacity of 131.4 l/s (3.0 mgd) the present worth of the aerated chamber is $83,755 compared to $141,000 for the swirl separator. Thus the present worth of the aerated chamber is 30 percent greater than that of the swirl separator.

For the 438 l/s (10.0 mgd) unit, the present worth of the aerated chamber is $303,615 compared to $219,280 for the swirl separator, or 38 percent greater.

TABLE 20

OPERATION AND MAINTENANCE COSTS FOR GRIT REMOVAL

	Aerated Chamber	Swirl Separator
Capacity 43.8 l/s (1.0 mgd)		
1. Labor		
Operation 1.5 hr/day @ $7.00/hr	$3,830	$3,830
Maintenance 0.2 hr/day @ $7.00/hr	510	510
2. Materials and Supplies	100	100
3. Power		
1 Compressor @ 1 hp, 24 hr/day x $0.04/kwh	350	---
1 Screw Conveyor @ 1/2 hp, 1 hr/day x $0.04/kwh	10	10
1 Bucket Conveyor @ 1/2 hp, 1 hr/day x $0.04/kwh	10	---
TOTAL ANNUAL COSTS	$4,910	$4,450
Capacity 131.4 l/s (3.0 mgd)		
1. Labor		
Operation 2.5 hr/day @ $7.00/hr	$6,490	$6,490
Maintenance 0.3 hr/day @ $7.00/hr	770	770
2. Materials and Supplies	300	190
3. Power		
1 Compressor @ 3 hp, 24 hr/day x $0.04/kwh	700	---
1 Screw Conveyor @ 1/2 hp, 3 hr/day x $0.04/kwh	30	30
1 Bucket Conveyor @ 1/2 hp, 3 hr/day x $0.04/kwh	30	---
TOTAL ANNUAL COSTS	$8,300	$7,430
Capacity 438 l/s (10.0 mgd)		
1. Labor		
Operation 4.5 hr/day @ $7.00/hr	$11,680	$11,680
Maintenance 0.5 hr/day @ $7.00/hr	1,280	1,280
2. Materials and Supplies	600	350
3. Power		
1 Compressor @ 6 hp, 24 hr/day x $0.04/kwh	2,100	---
1 Screw Conveyor @ 1/2 hp, 6 hr/day x $0.04/kwh	60	60
1 Bucket Conveyor @ 1/2 hp, 6 hr/day x $0.04/kwh	60	---
TOTAL ANNUAL COSTS	$15,780	$13,250

TABLE 31

PRESENT WORTH
GRIT REMOVAL UNITS

Capacity 43.8 l/s (1.0 mgd)

	Aerated Chamber	Swirl Separator
Construction Cost	$89,885	$ 49,000
Operation and Maintenance Cost	36,000	51,000
COST TOTAL PRESENT WORTH	$125,885	$100,000

Capacity 131.4 l/s (3.0 mgd)

Construction Cost	$89,755	$ 57,000
Operation and Maintenance Cost	94,000	84,000
TOTAL PRESENT WORTH	$183,755	$141,000

Capacity 438 l/s (10.0 mgd)

Construction Cost	$124,965	$ 68,890
Operation and Maintenance Cost	178,650	130,390
TOTAL PRESENT WORTH	$303,615	$219,280

REFERENCES

1. Sullivan, Richard H. The Swirl Concentrator as a Combined Sewer Overflow Regulator Facility. EPA-R2-72-008 (NTIS No. PB-214-687), U.S. Environmental Protection Agency, September, 1972. 179 pp.

2. Sullivan, Richard H., et al. The Swirl Concentrator as a Grit Separator Device. EPA-670/2-74-036 (NTIS No. PB-234-175/8) U.S. Environmental Protection Agency, June, 1974. 93 pp.

3. Chaetck, A.H. and Bugher, Theodore R. Using Graded Sand to Test Grit Removal Apparatus. Journal of the Water Pollution Control Federation. Vol. 36, No. 7 p. 884, July, 1964.

4. American Society of Civil Engineers and The Water Pollution Control Federation. Design and Construction of Sanitary and Storm Sewers. ASCE-Manual and Reports on Engineering Practice - No. 37 (WPCF Manual of Practice No. 9). 1969. p. 33.

[redacted]

[redacted]

[redacted]

Sample	Space (ft^2/day)	Area Rate (lbs/day)	Total Solids (%)	Vol. Total Solids (%)	Susp. Solids (mg/l)	Vol. Susp. Solids (mg/l)	Putrescibles (%)	BOD (5 d, 20°C) (mg/l)	COD (mg/l)
[redacted]	0.55	0.84	-	54.3 *	-	-	-	-	-
[redacted]	0.38	1.13	-	53.1 *	-	-	-	-	-
[redacted]	0.625	0.74	-	54.2 *	-	-	-	-	-
[redacted]	75.1	-	35.1	45.7	-	-	1.4 *	-	-
[redacted]	57.1	-	42.7	18.6	-	-	0.8 *	-	-
[redacted]	-	-	-	-	2495	1938	9.1 *	-	-
[redacted]	-	-	-	-	728	385	0.9 *	-	-
[redacted]	-	-	-	-	266	199	-	158 (2d)**	385 (2d)**
[redacted]	-	-	-	-	249	193	-	-	-
[redacted]	-	-	-	-	249**	204**	-	138 (24h)**	322 (24h)**
[redacted]	-	-	-	-	184**	143**	-	-	-

A.S.C. = Aerated Grit Chamber
B.S.C. = Secondary Clarifier
R.C. = Return Concentrate
Inf. = Influent
Eff. = Effluent
P.T. = Primary Influent

ASC flow 46.3 mgd

* = Average of 2 samples/week

** = Average weekly, flow adjusted

* = Single sample analysis

TABLE A-3

[illegible] MGD, FLOW 87.6 l/s (2.0 mgd)
MAY 31 - JUNE 6, 1975

Sample	Grit (lbs/1000 lbs)	Grit, Dry (lbs/day)	Total Solids (%)	Vol. Total Solids (%)	Susp. Solids mg/l	Vol. Susp. Solids mg/l	Putrescible (%)	BOD (5 day) mg/l	COD mg/l
Chamlick # 1	0.35	8.34	-	38.8 *	-	-	-	-	-
Chamlick # 2	0.37	3.55	-	41.9 *	-	-	-	-	-
Chamlick # 3	0.41	2.89	-	78.4 *	-	-	-	-	-
Grit S.C. Post-Wash	38.4	-	48.6	75.1	-	-	2.4 *	-	-
Grit D.O.C. Eff.	52.1	-	84.6	19.8	-	-	1.3 *	-	-
Grit S.C. Pre-Wash	-	-	-	-	1138	788	Not Run	-	-
Grit D.O.C. Inf.	-	-	-	-	998	758	Not Run	-	-
A.G.C. # 1 Inf.	-	-	-	-	333	284	-	176 (380)**	424 (1380)**
Setzl Eff.	-	-	-	-	333	173	-	-	-
A.G.C. # 2 Inf.	-	-	-	-	[illegible]	[illegible]	-	170 (340)**	420 (1360)**
P.I.	-	-	-	-	[illegible]	157**	-	-	-

A.G.C. - Aerated Grit Chamber
D.O.C. - Dorr-Oliver Classifier
S.C. - Setzl Concentrator
Inf. - Influent
Eff. - Effluent
P.I. - Primary Influent

AVG FLOW 38.7 mgd

* - Average of 2 samples/week
** - Average weekly, flow adjusted
\- Single sample analysis

TABLE A-3

TEST DATA SHEET, PLANT [illegible] (3.8 mgd)
JUNE 12-th AND 25-th, 1975

Sample	Grit (ft³/day)	Grit, Dry (lbs/day)	Total Solids (%)	Vol. Total Solids (%)	Susp. Solids (mg/l)	Vol. Susp. Solids (mg/l)	Putrescibles (%)	BOD (5day) (mg/l)	COD (mg/l)
Chamlick # 1	8.33	9.48	-	17.5 *	-	-	-	-	-
Chamlick # 2	8.47	3.37	-	61.4 *	-	-	-	-	-
Chamlick # 3	8.45	2.33	-	66.9 *	-	-	-	-	-
Grit S.C. Pract-Wash	16.1	-	57.8	23.6	-	-	1.6**	-	-
Grit D.O.C. Eff.	67.5	-	67.2	17.3	-	-	0.2**	-	-
Grit S.C. Pre-Wash	-	-	-	-	344	298	0.8**	-	-
Grit D.O.C. Inf.	-	-	-	-	347	271	2.5**	-	-
A.C.C. # 1 Inf.	-	-	-	-	219	173	-	135 (280)**	384 (395)**
Swirl Eff.	-	-	-	-	95	156	-	-	-
A.C.C. # 2 Inf.	-	-	-	-	69**	58**	-	163 (242)**	383 (425)**
P.I.	-	-	-	-	167**	112**	-	-	-

A.C.C. = Aerated Grit Chamber
D.O.C. = Dorr-Oliver Classifier
S.C. = Swirl Concentrator
Inf. = Influent
Eff. = Effluent
P.I. = Primary Influent

at flow of 3.8 mgd

* = average of 3 samples/week
** = Average weekly, flow adjusted
*** = Single sample analysis

[illegible]

[illegible]

[illegible]

TABLE A-5

[illegible]
[illegible]

[illegible]	Condition #	Sample #	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
1	2	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
	*3	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
	*1	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
2	2	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	S
	*3	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
	*1	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
3	*2	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
	*3	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
	*1	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
4	*2	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	S
	*3	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
	*1	5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
5	*2	5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	S
	*3	5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

[illegible]:

* [illegible]

S = [illegible]

Table 6-6

TEST DATA SHEET, Plate 87.6 1/4 (2.0 mph)
AUGUST 29, 1975

RUN	CONTROL #	SAMPLE #	CELL cu ft/hr	DRY WEIGHT lbs/hr	% vol. ave.	SIEVE ANALYSIS, % PASSED Tyler U.S. SIEVE NUMBER 100	65	35	20	12	5	PAN
	*1	1	0.033	0.305	43.8	17.4	32.3	54.3	73.8	91.8	97.7	
1	*2	1	0.037	0.226	54.0	23.2	40.5	59.4	75.4	89.2	96.5	
	*3	1	0.040	0.175	64.6	39.2	61.2	78.1	88.7	96.5	99.6	
	*1	2	0.037	0.695	21.6	9.7	32.1	79.8	91.8	97.1	99.1	
2	*2	2	0.040	0.541	37.6	18.4	47.5	77.7	88.2	95.8	98.6	S
	*3	2	0.053	0.736	70.9	44.2	65.8	81.8	91.7	97.2	98.9	
	*1	3	0.038	0.689	22.4	6.9	28.9	52.9	75.3	92.8	98.4	
3	*2	3	0.055	0.382	43.4	23.2	56.9	82.9	97.4	99.4	99.7	S
	*3	3	0.065	0.341	70.8	42.7	62.7	77.1	88.5	96.5	99.4	
	*1	4	0.035	0.579	20.9	8.1	23.6	61.3	82.7	96.4	98.6	
4	*2	4	0.037	0.336	37.9	22.9	54.4	87.3	96.3	98.4	99.7	S
	*3	4	0.045	0.321	71.9	32.3	49.4	66.5	81.2	96.1	97.4	
	1	5	0.038	1.339	48.5	6.4	36.4	68.7	75.0	92.4	98.3	
5	*2	5	0.050	0.364	68.8	24.0	38.1	57.3	71.9	85.4	94.8	
	*3	5	0.075	0.253	75.5	48.9	72.3	90.0	96.4	99.3	100.0	

NOTES:

*See Table

S = Flow Splitter with Sweat

| | | |

TABLE A-8

[illegible]

Date	Time	Total ADC Flow-mgd	Influent Sampler No. 1 Flow gpm	Influent Sampler No. 1 Grit Volume Quarts	Effluent Sampler No. 3 Flow gpm	Effluent Sampler No. 3 Grit Volume Quarts
4/28/74	7:30 am	35	21.8	2.25	21.8	2.5
	9:30 am	50	21.8		21.8	
	10:30 am	70	21.8		21.8	
	12:30 pm	66	21.8	2.0	21.8	2.25
4/29/74	8:00 am	22.3	21.8		21.8	
	9:00 am	34.5	21.8		21.8	
	10:00 am	42	21.8	2.0	21.8	2.0
	11:00 am	41	21.8		21.8	
	12:00 am	66	21.8	3.75		3.5
4/30/74	8:00 am	23.5	21.8		21.8	
	9:00 am	34	21.8	2.0	21.8	1.75